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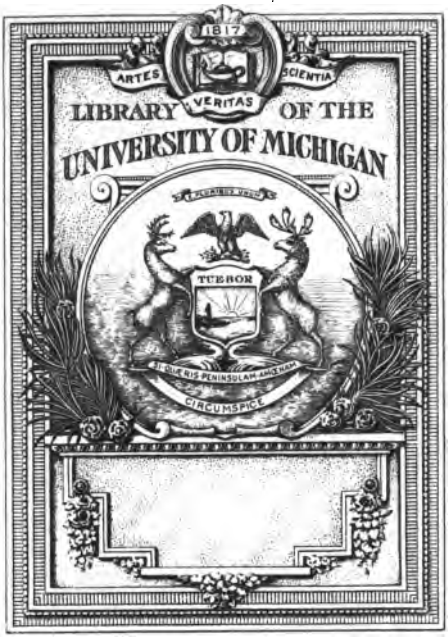
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BULLETIN No. 25. Agros. 88.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF AGROSTOLOGY.
[Grass and Forage Plant Investigations.]

FIELD WORK OF THE DIVISION OF AGROSTOLOGY:

A REVIEW AND SUMMARY OF THE WORK DONE SINCE THE ORGANIZATION OF THE DIVISION, JULY 1, 1895.

184

BY

CORNELIUS L. SHEAR,
Assistant Agrostologist.

PREPARED UNDER THE DIRECTION OF F. LAMSON-SCRIBNER, AGROSTOLOGIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1901.

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF AGROSTOLOGY,
Washington, D. C., June 15, 1901.

SIR: I have the honor to transmit herewith the manuscript of a report on the "Field Work of the Division of Agrostology," by Cornelius L. Shear, assistant in this Division in charge of seed and field work, and to recommend its publication as Bulletin No. 25 of this Division. This report is a comprehensive statement of the work done in the field by the Division of Agrostology since its organization July 1, 1895, together with a summary of the results accomplished in the way of new discoveries and the development of useful species of grasses and forage plants.

Respectfully,
F. LAMSON-SCRIBNER,
Agrostologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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FIELD WORK OF THE DIVISION OF AGROSTOLOGY: A REVIEW AND SUMMARY OF THE WORK DONE SINCE THE ORGANIZATION OF THE DIVISION, JULY 1, 1895.

INTRODUCTION.

The Division of Agrostology was established by Congress in 1895 for the purpose of investigating the various problems relating to the grasses and forage plants of the United States. Progressive farmers, stockmen, and dairymen had for some time recognized that there was urgent need of a thorough study of the various forage problems which were presenting themselves in different parts of the country. Consequently the then Secretary of Agriculture, Hon. J. Sterling Morton, recommended to Congress that a separate Division be established to take charge of and prosecute the work. The rapidly deteriorating condition of the native meadows and ranges of the great West naturally led the stockmen to inquire into the reasons for these conditions, and to try to ascertain what steps might be taken to improve them. The very rapid development of the stock-growing industry in the West, which immediately followed the building of the transcontinental railroads, brought about increasing competition for the use of the grazing lands, and under the mistaken impression that the abundant forage at first found was practically inexhaustible, together with the effort on the part of each to secure as much advantage as possible from the "free grass," great injury naturally resulted to the grazing lands.

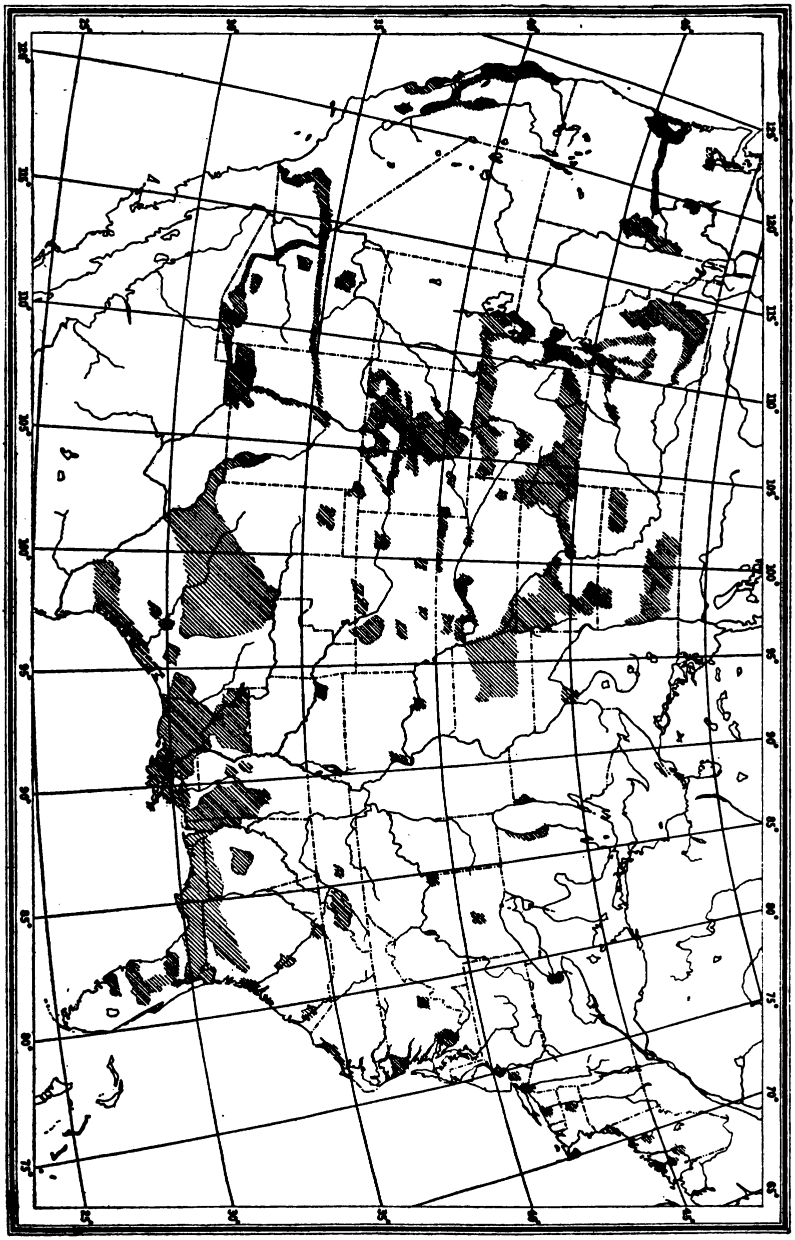
The stock-growing industry is one of great importance and one that should be carefully fostered. The vast areas of land throughout the Western States and Territories, which are at present unavailable for general agricultural purposes, and the greater part of which probably never will be available for such use on account of the insufficient water supply, should be properly controlled so as to conserve their usefulness.

Of the unoccupied public lands about 365,400,000 acres are regarded at present as fit only for grazing purposes. There are, in addition, 124,300,000 acres of forest land, the greater portion of which is also used for grazing. The various evils arising from overstocking and denuding extensive areas of grazing and timber lands bear such a direct relation to the general welfare of the whole West that it is incumbent upon the General Government to make a thorough investigation of all the questions involved and if possible devise some means of remedying the present conditions. The relation of the grazing industry to forest reserves, to the water supply, to erosion, and the various other matters to which it more or less directly relates can not be solved except by long and careful investigation of the actual facts and conditions prevailing. While the problems presented by the vast semi-arid grazing regions of the West seemed most urgent, there were also important questions in the other portions of the country pressing for solution. The questions involved required, first of all, a thorough and accurate knowledge of the actual facts and conditions existing. Thus, field work was commenced as soon as the Division was established in order that the necessary data might be secured as a basis for future work and recommendations.

PERSONS ENGAGED AND TERRITORY COVERED.

The field work of the Division has been carried on by different members of the regular office force and by special agents employed for certain periods during the summer season. Twenty-seven persons in all have been engaged at different times in the work. The following is a list of those who have done field work, with the names of the States or Territories in which such work has been done:

C. R. Ball, 1898, 1900, 1901	Alabama, Louisiana, Mississippi, South Carolina.
E. A. Bessey, 1898	Colorado.
M. A. Brannon, 1896	North Dakota.
Edw. R. Chase, 1895	Utah.
F. E. Clements, 1896	Colorado.
R. Combs, 1898	Florida.
J. B. Davy, 1899	California.
C. J. Elmore, 1896	Nebraska.
C. C. Georgeson, 1898	Texas.
David Griffiths, 1896–97	Arizona, Montana, South Dakota, Wyoming.
T. H. Kearney, 1895	Alabama, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Virginia.
Emil F. Lange, 1900	Montana.
A. B. Leckenby, 1898–1900	Washington, Oregon.
E. D. Merrill, 1900	Idaho, Minnesota, Montana, Wisconsin, Wyoming.
Aven Nelson, 1897	Wyoming.
Elias Nelson, 1900	Wyoming.
C. R. Orcutt, 1896	Arizona, California, New Mexico, Texas.
L. H. Pammel, 1896	Colorado, Iowa, Nebraska, South Dakota, Wyoming.
P. A. Rydberg, 1895–96	Colorado, Idaho, Montana, Nebraska, Utah, Wyoming.



TOTAL TERRITORY COVERED BY THE FIELD WORK OF THE DIVISION OF AGROSTOLOGY, 1895-1900.

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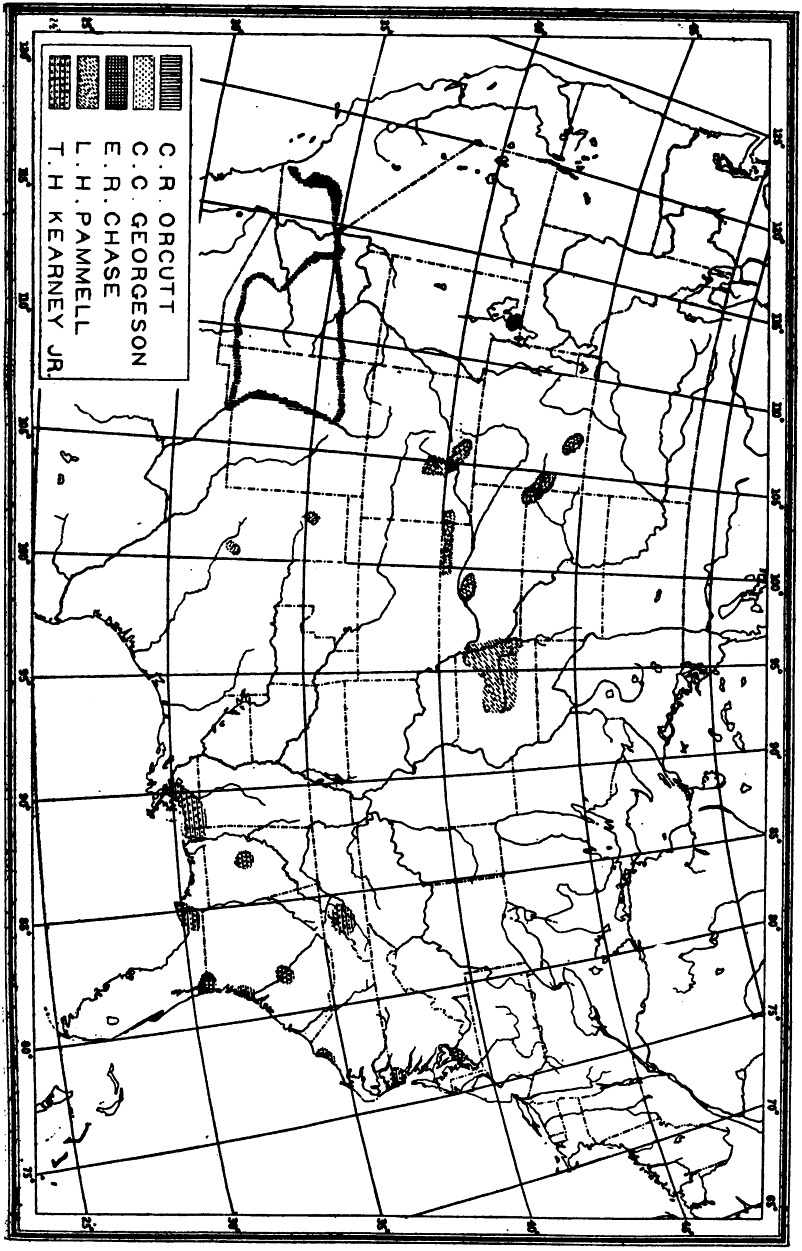
Bul. 25, Div. of Agrostology, U. S. Dept. of Agriculture. **MAP 2.**



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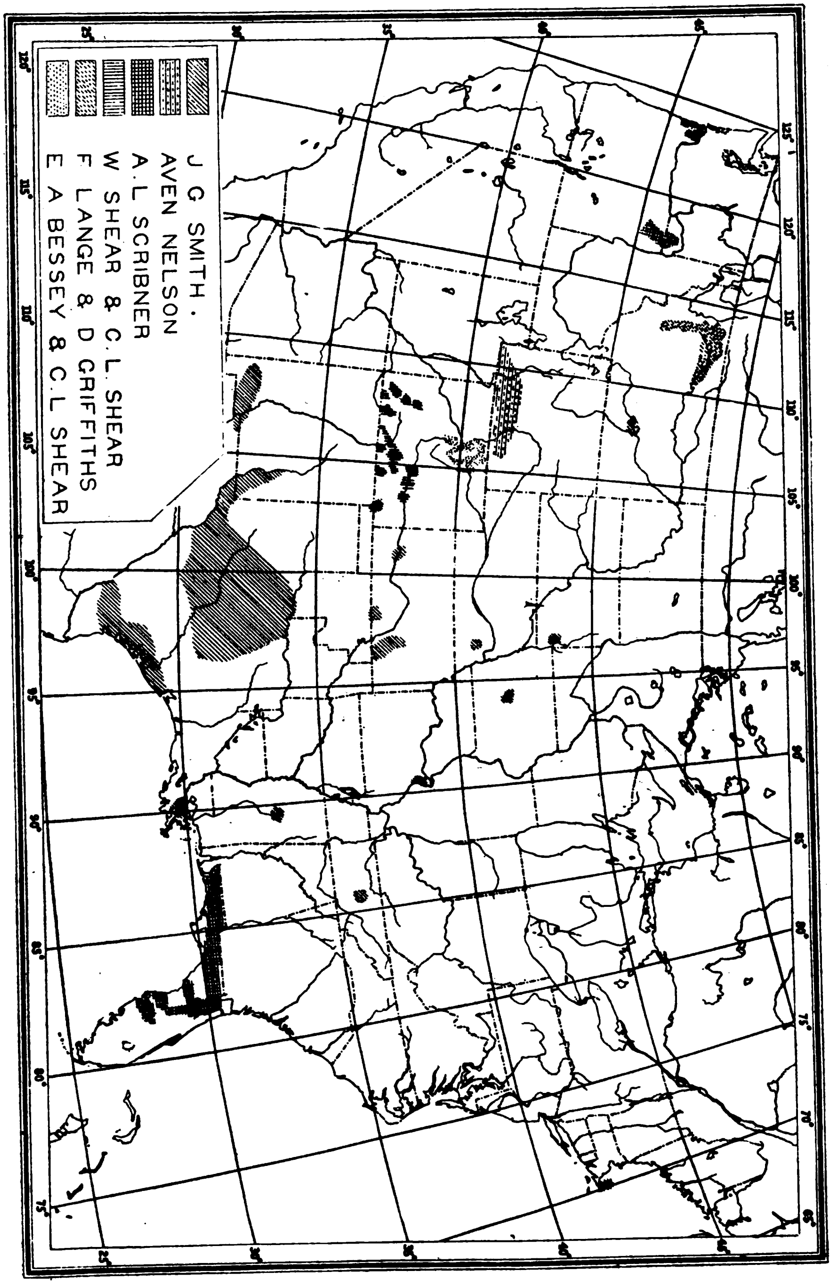

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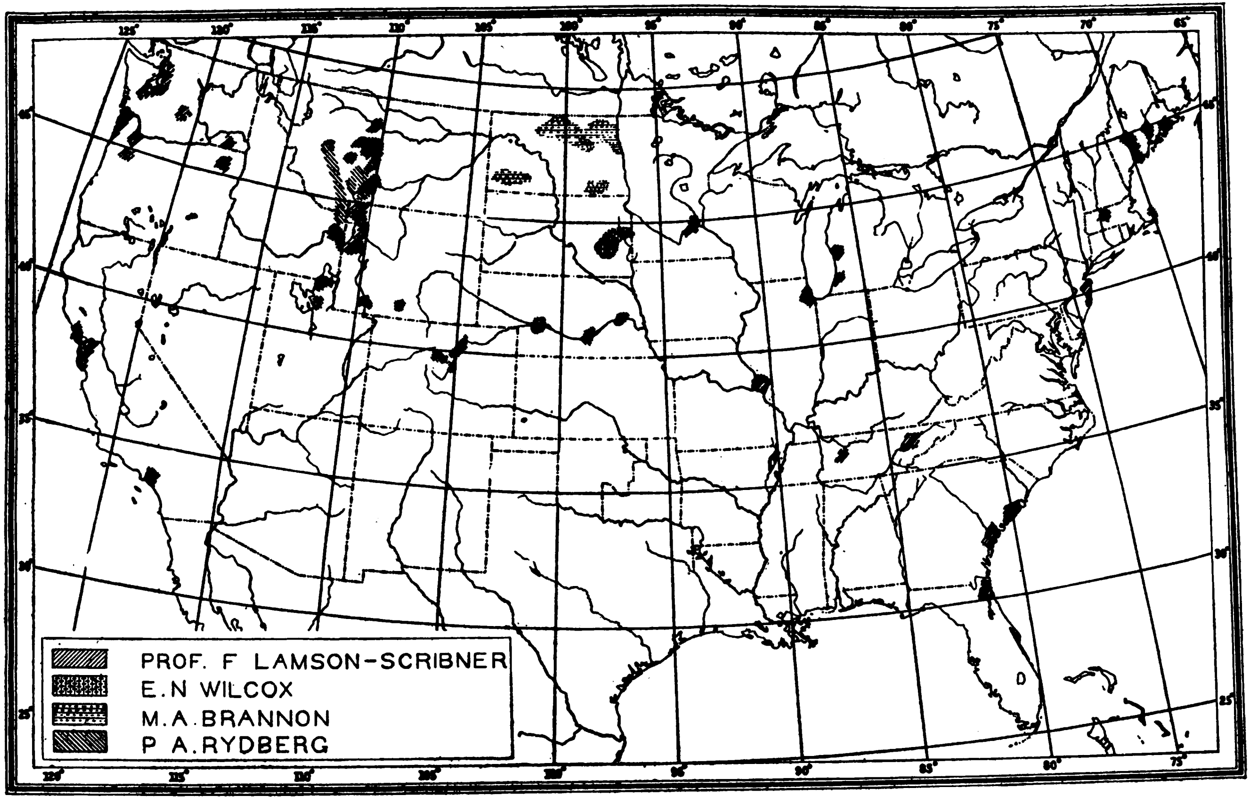

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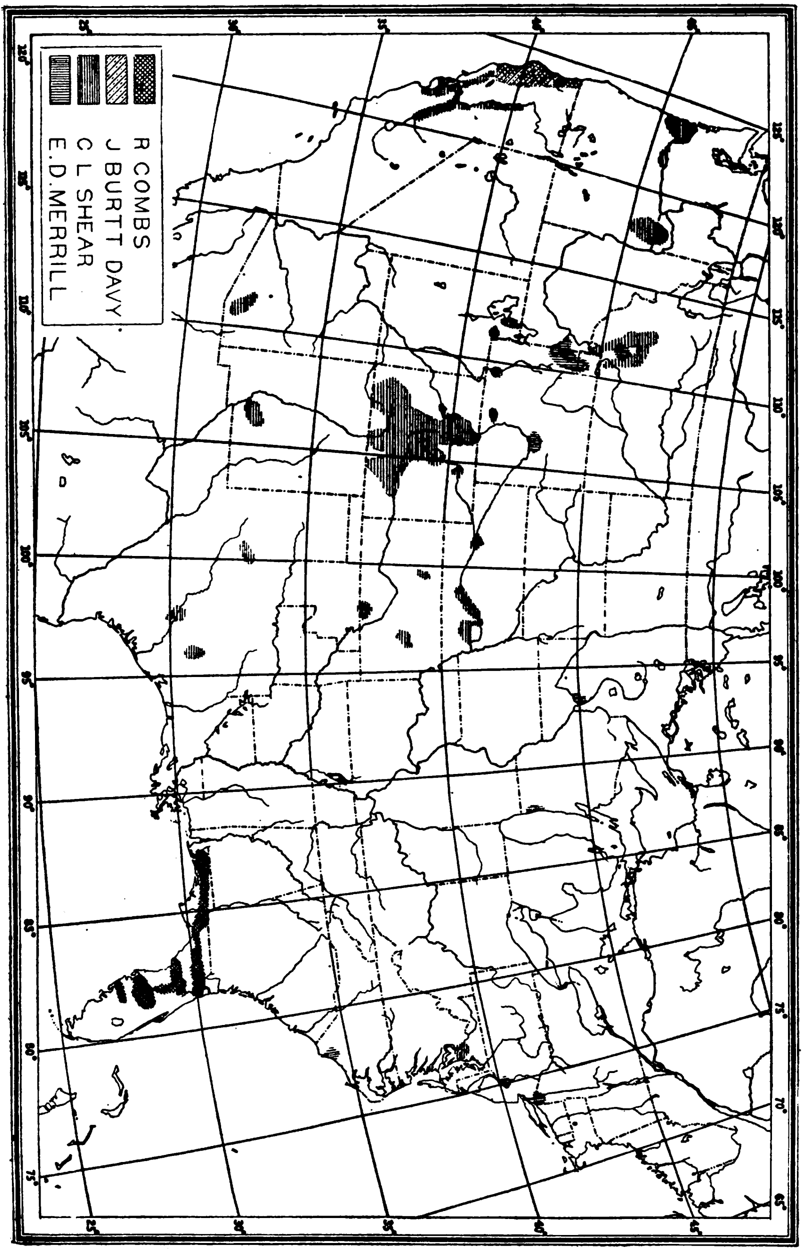
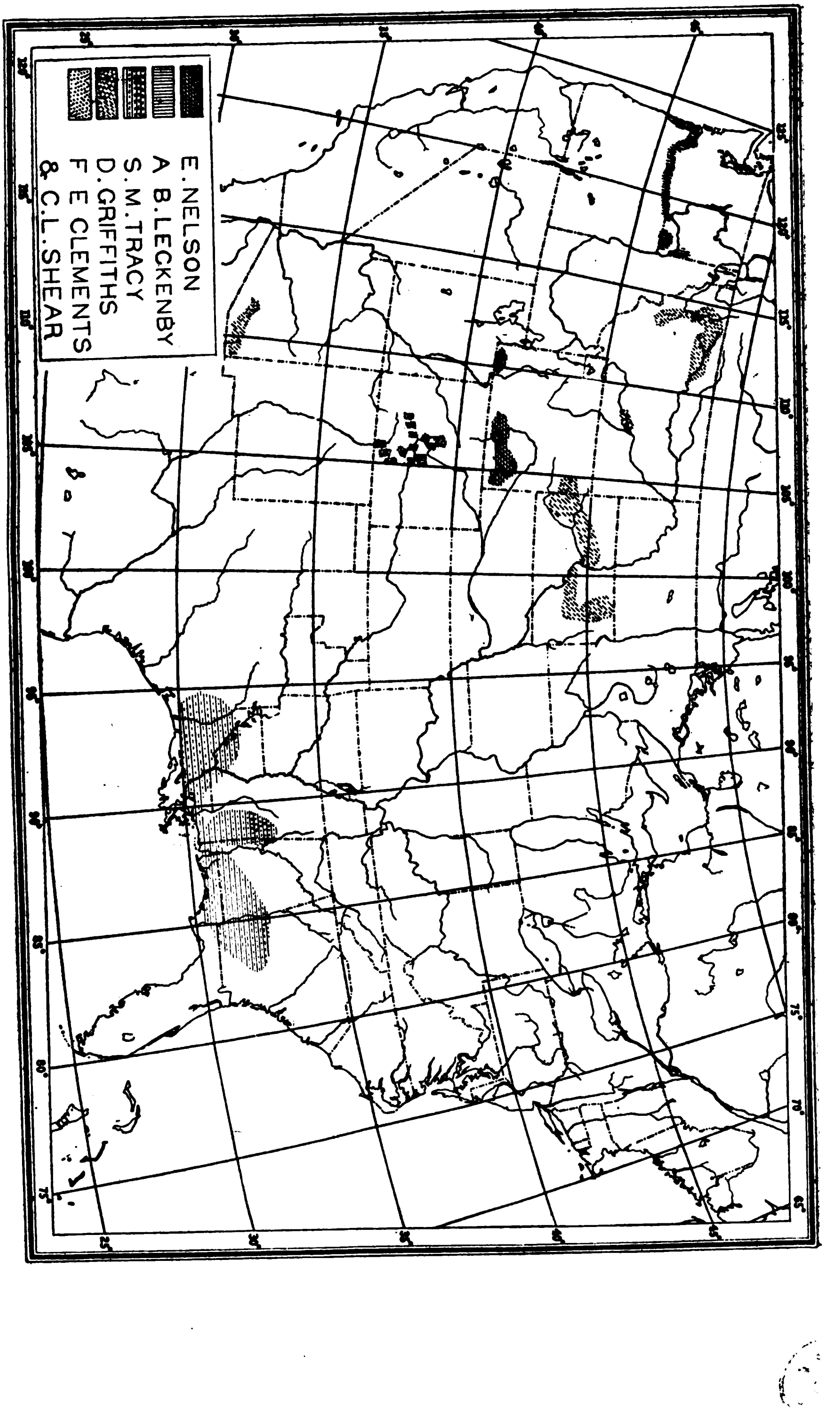


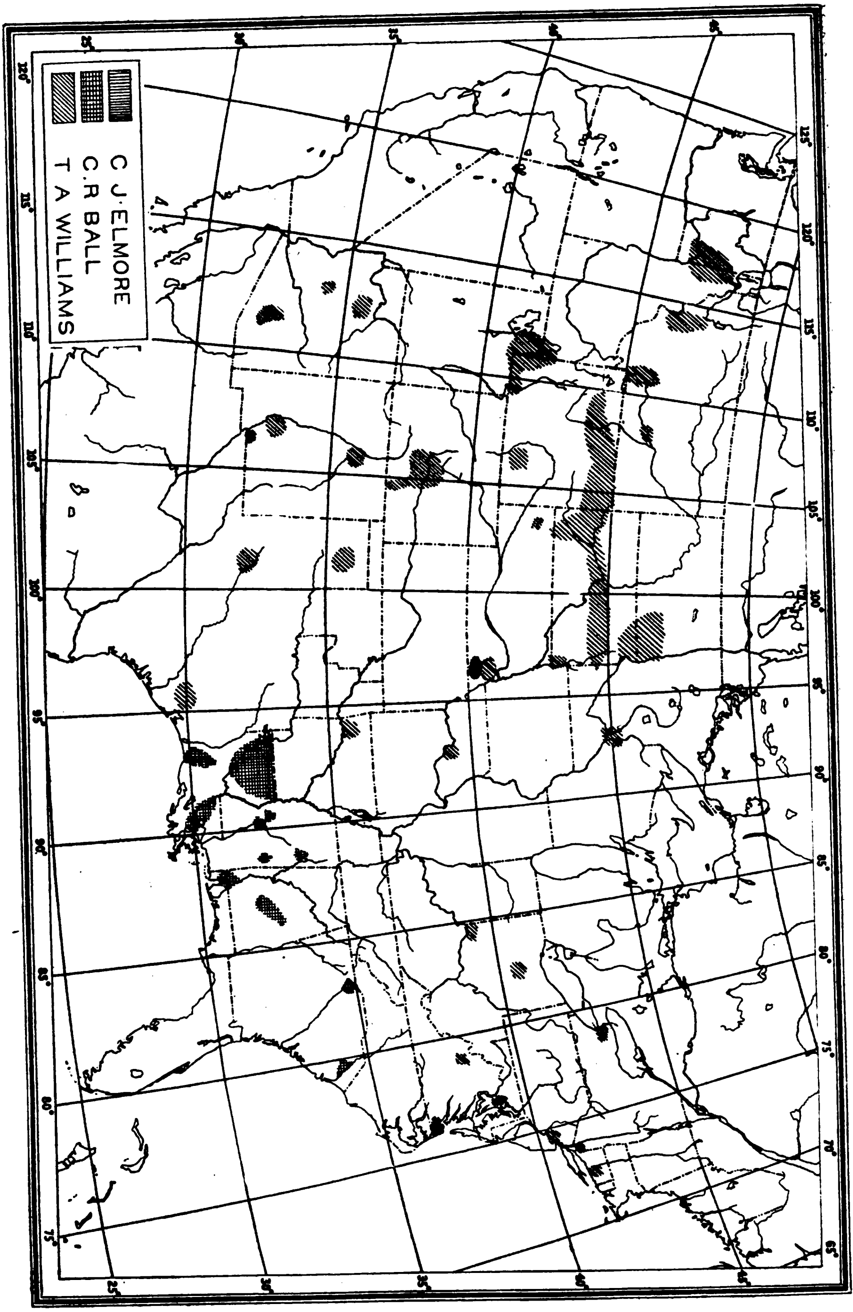
FIELD WORK OF THE DIVISION OF AGROSTOLOGY.

MAP 6.



FIELD WORK OF THE DIVISION OF AGROSTOLOGY.

MAP 7.



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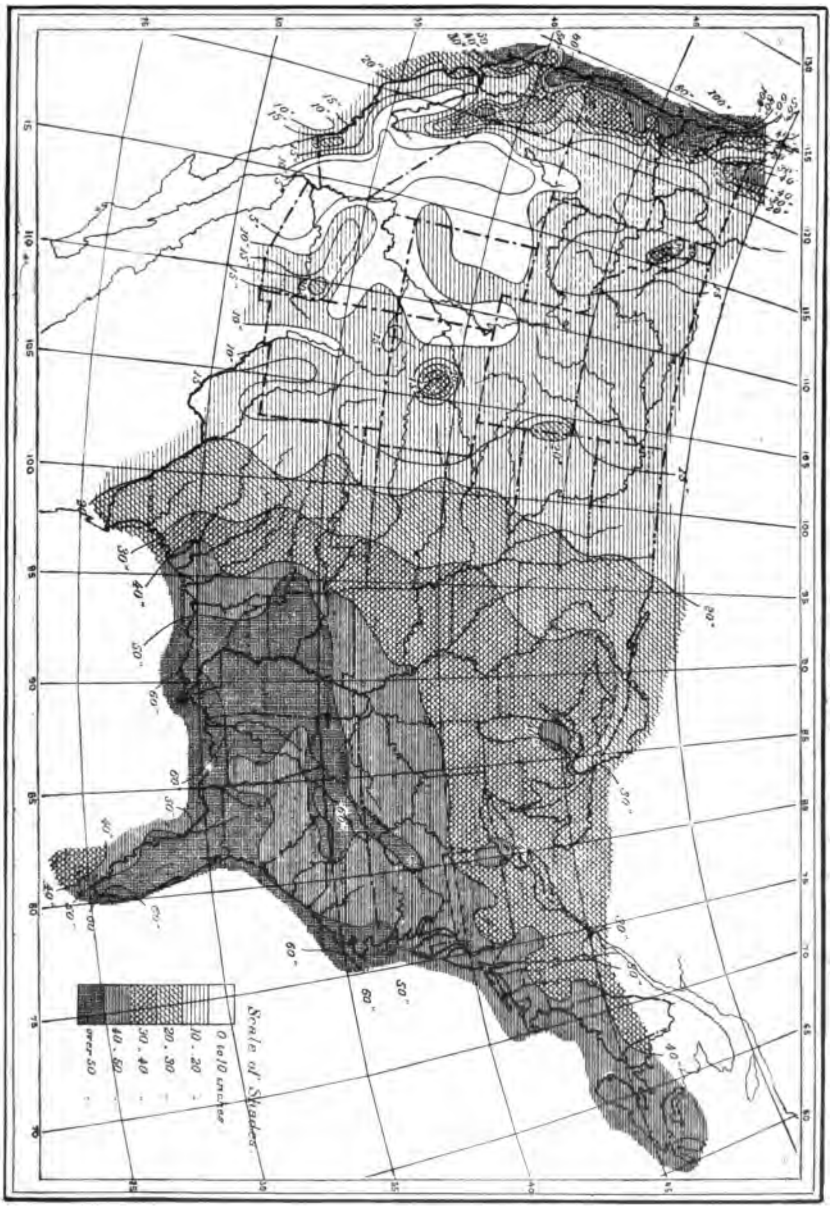


AMOUNT AND DISTRIBUTION OF THE ANNUAL PRECIPITATION. (AFTER WEATHER BUREAU CHART.)

F. Lamson-Scribner, 1896–1900	California, Florida, Idaho, Maine, Massachusetts, Michigan, Oregon, South Carolina, Washington, Wyoming.
A. Lamson-Scribner, 1900	Florida, Massachusetts, Oregon, Washington.
C. L. Shear, 1895–1901	Arizona, California, Colorado, Idaho, Kansas, Maryland, Montana, Nebraska, New Mexico, Oregon, Texas, Utah, Washington, Wyoming.
J. G. Smith, 1895–1898	Colorado, Iowa, Kansas, Louisiana, Mississippi, Missouri, Nebraska, New Mexico, South Dakota, Tennessee, Texas.
William Shear, 1900	Colorado.
S. M. Tracy, 1897	Alabama, Florida, Georgia, Louisiana, Mississippi, Texas.
E. N. Wilcox, 1897	South Dakota.
T. A. Williams, 1896–1900	Arizona, Arkansas, Colorado, Connecticut, Idaho, Maryland, Minnesota, Missouri, Montana, New Jersey, New Mexico, New York, North Dakota, Ohio, South Dakota, Texas, Utah, Virginia, Washington, Wyoming.

It will be observed from this list that the greatest amount of work has been done in the South, on the Great Plains, and in the Rocky Mountain region. The work in these regions was naturally undertaken first on account of our insufficient knowledge of the forage plants and conditions and on account of the great importance of the forage problems in these regions.

PREVIOUS INVESTIGATIONS.

At the beginning of the investigations by the Division exact knowledge of the grasses and forage plants of the greater part of the range lands of the country west of the Mississippi River was very limited. Some field work had been done in certain portions of the West under the direction of Dr. George Vasey, former botanist of the Department of Agriculture. The various Government surveying parties had made collections of more or less importance at various places, and a few private collectors had also done considerable work in this direction.[1] The greater part of this work, however, had been devoted to the collection of the plants found, without giving special attention to the relative value and importance of the species as forage.

PRINCIPAL PROBLEMS AND REQUIREMENTS AT THE BEGINNING OF THE WORK.

While the purely botanical explorations of this part of the country had afforded material for a catalogue of most of our grasses, yet very little was known of their distribution, abundance, and relative value for forage purposes. It was quite essential that accurate knowledge should be secured in regard to these matters and that field investigations should be undertaken with this particular end in view. Conflicting accounts had been received from stockmen and ranchmen with regard to the different grasses, their value, abundance, and distribution. Unfortunately reports from such sources can not always be relied upon, as the parties making them have rarely had sufficient training in accurate observation and comparison of plants to arrive at correct conclusions. The grasses are so numerous and the characteristics distinguishing the species are in many cases so inconspicuous that only the trained agrostologist can distinguish them. Another liability to confusion results from lack of uniformity in the application of the common names of grasses.

---

[1] See preface to Bull 16, Div. Agrost. for further account of work previous to the establishment of this Division.

Another question of great importance was the actual condition of the pasture and range lands and the causes which have led to their present condition. The conditions vary greatly in different places, so that only by actual inspection of the greater portion of the range lands could a just estimate be made. The fact that, as a general thing, the ranges were becoming impaired was generally admitted, but to just what extent, and as a result of what causes, it was very important to accurately ascertain. Some were disposed to account for it largely on the supposition that there was less annual precipitation than formerly. The validity of this statement was easily determined, however, by reference to the Weather Bureau records, which, though in some cases not extending over a sufficient number of years to determine the question with absolute certainty, yet were sufficient to indicate that there was not enough, if any, decrease in the average rainfall to account for the great deterioration of the range lands. The effectiveness of the rainfall, however, is much less at present than formerly, but this is the result of the present condition of the ranges rather than its cause, and involves the question of the effect of overgrazing upon the conservation of the water supply and upon erosion—questions of great importance, which demand careful and thorough investigation. Whereas overgrazing was generally admitted to be the fundamental cause of most of the trouble, it was important to learn exactly to what extent the ranges were being overstocked and the exact manner in which the resulting injury occurs.

Field workers were instructed to make a thorough investigation of all the matters above referred to by a careful examination of the ranges and meadows and also by inquiry from stockmen and ranchmen. They were also instructed to make collections of all the native grasses and forage plants with full notes regarding their forage value, abundance, past and present distribution, and also to collect seeds of all the valuable species, particularly those giving indications of usefulness under cultivation. In cases where seed could not be secured

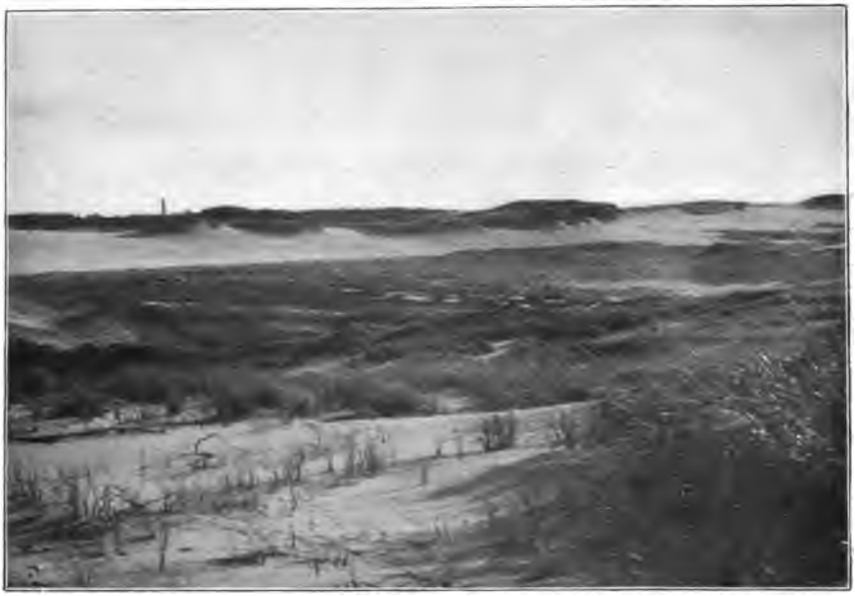


FIG. 1.—VIEW AT CAPE COD, MASS., SHOWING SAND DUNES AND GENERAL APPEARANCE OF THE COUNTRY.

From a photograph by F. Lamson-Scribner.

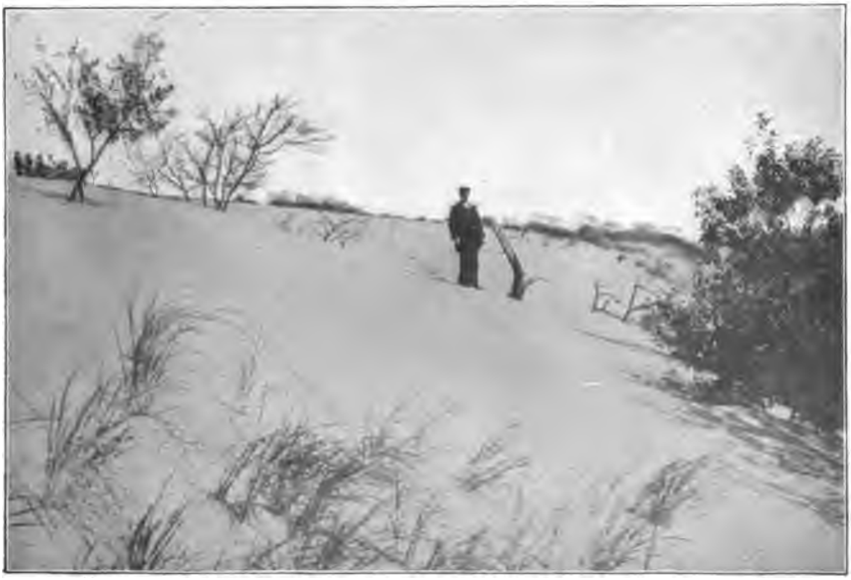


FIG. 2.—VIEW AT CAPE COD, MASS., SHOWING SAND DRIFTS BURYING FOREST TREES.

From a photograph by F. Lamson-Scribner.

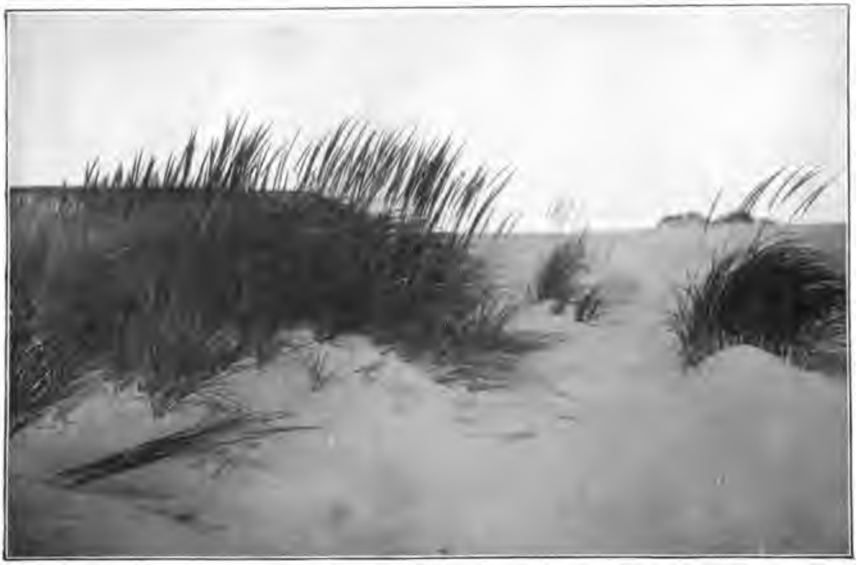


FIG. 1.—NATURAL GROWTH OF BEACH GRASS (AMMOPHILA ARENARIA) AT CAPE COD, MASS.

From a photograph by F. Lamson-Scribner.

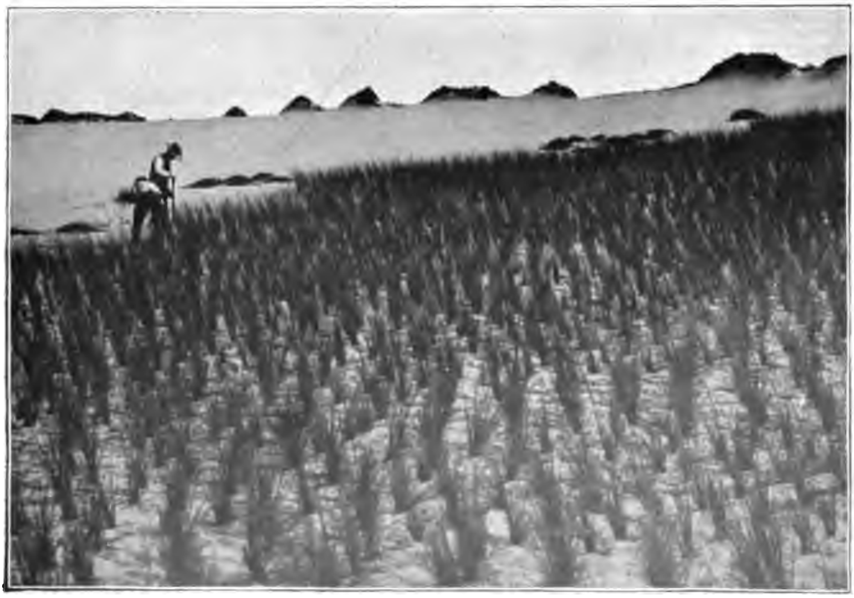


FIG. 2.—PLANTING BEACH GRASS (AMMOPHILA ARENARIA) AT CAPE COD, MASS.

From a photograph by F. Lamson-Scribner.

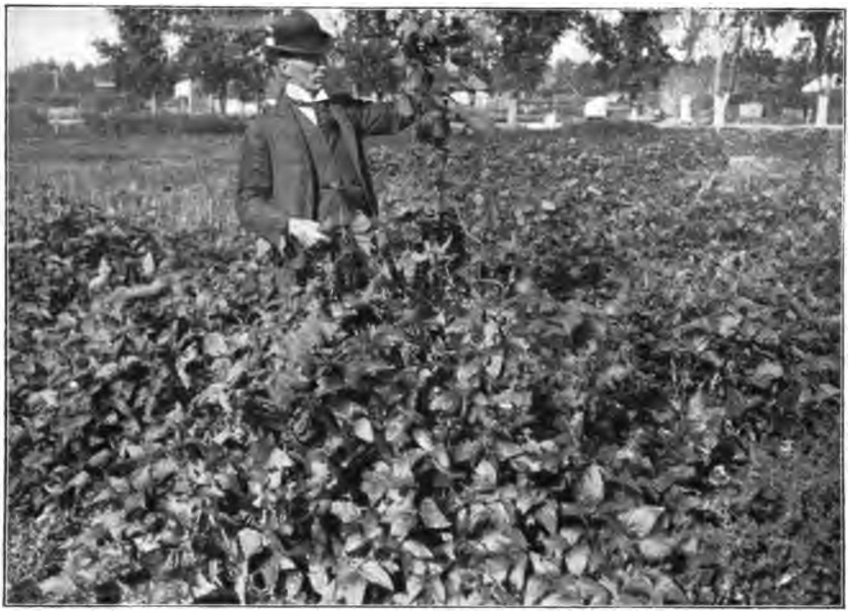


FIG. 1.—CHINESE SOY BEAN (GLYCINE HISPIDA VAR.). GROWN ON POTOMAC FLATS, WASHINGTON, D. C.

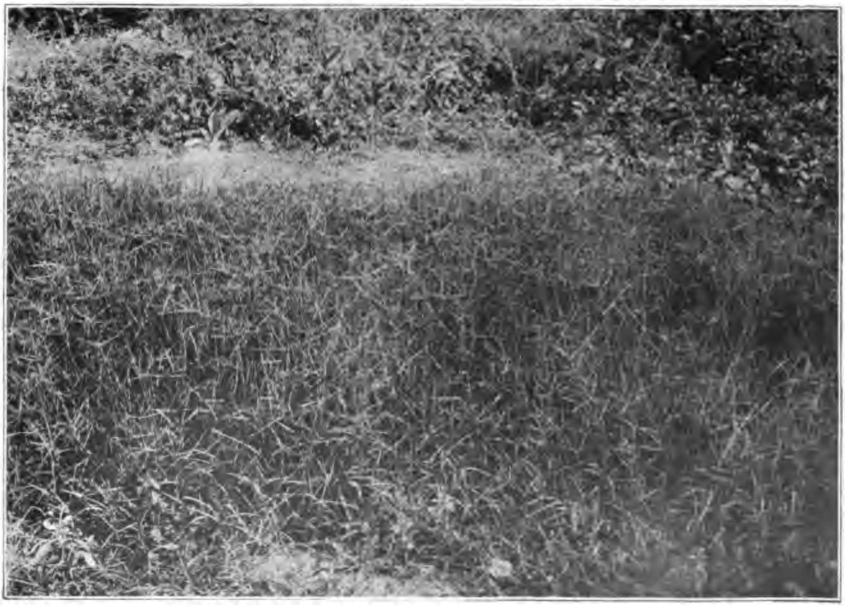


FIG. 2.—BERMUDA GRASS.

roots were obtained for transplanting in order that a careful study of the plants might be made under cultivation to demonstrate if possible the practicability of their general use.

REVIEW OF THE FIELD WORK BY REGIONS.

ATLANTIC COAST.

Besides forage problems the Division was charged with the investigation of grasses as soil and sand binders. The extensive areas of shifting sands along the Atlantic coast have for many years attracted attention and led to efforts to devise some means of holding them. Besides the interference with navigation frequenty caused by the shifting of these sands there is a continual destruction of the agricultural lands bordering the coast by the gradual encroachment of the drifting sand. Investigations along this line have been made on the coast near Provincetown, Mass. on Cape Cod, where there are extensive areas of shifting sands, and experiments in growing and transplanting sand-binding grasses have been carried on (Pl. I). The beach grass (*Ammophila arenaria*) which is native along the Atlantic coast has been very useful in preventing the drifting of the sand and has been transplanted over quite extensive areas on Cape Cod under the authority of the State of Massachusetts (Pl. II). Investigation of the native sand-binding grasses has also been made at various other points along the Atlantic coast, and it has been found that there are a number of very valuable native grasses which act as sand binders. Besides the beach grass, which is not indigenous south of Virginia, there is the sand rye-grass (*Elymus arenarius*), occurring from Massachusetts northward; the bitter panic (*Panicum amarum*), extending from Connecticut south along the Atlantic and Gulf coast, and sea oats (*Uniola paniculata*), another important sand binder occurring from Virginia southward and along the Gulf coast. Experiments have demonstrated that these grasses can be readily transplanted and very successfully used in preventing the drifting of the sands. Besides the transplanting of roots of sand-binding grasses large quantities of seed, especially of the beach grass, have been secured from Provincetown, Mass., for distribution and trial at various points, not only along the seacoast but also along the shores of the Great Lakes where similar trouble is caused by the shifting sand. The Chief of the Division has investigated the question of sand binders at several points on the Maine coast; at Cape Cod, Massachusetts, and also in the vicinity of Charleston, S. C., and Savannah, Ga., where, at the request of the War Department, experiments were undertaken in preventing the shifting of sand in the vicinity of the fortifications.

Mr. Allen Scribner did field work on Cape Cod, collecting a large quantity of beach-grass seed as well as a considerable number of roots for transplanting.

Mr. T. A. Williams, late assistant chief of the Division, did work in the vicinity of Norfolk, Va., securing seeds and roots of the bitter panic grass and a closely related species, which was considered new, and has been described in Circular No. 29 of this Division as *Panicum amaroides*, Scribn. & Merrill.

Mr. T. H. Kearney, formerly an assistant in the Division, also did field work at Norfolk, Va.; Wilmington, N. C., and Savannah and Augusta, Ga.

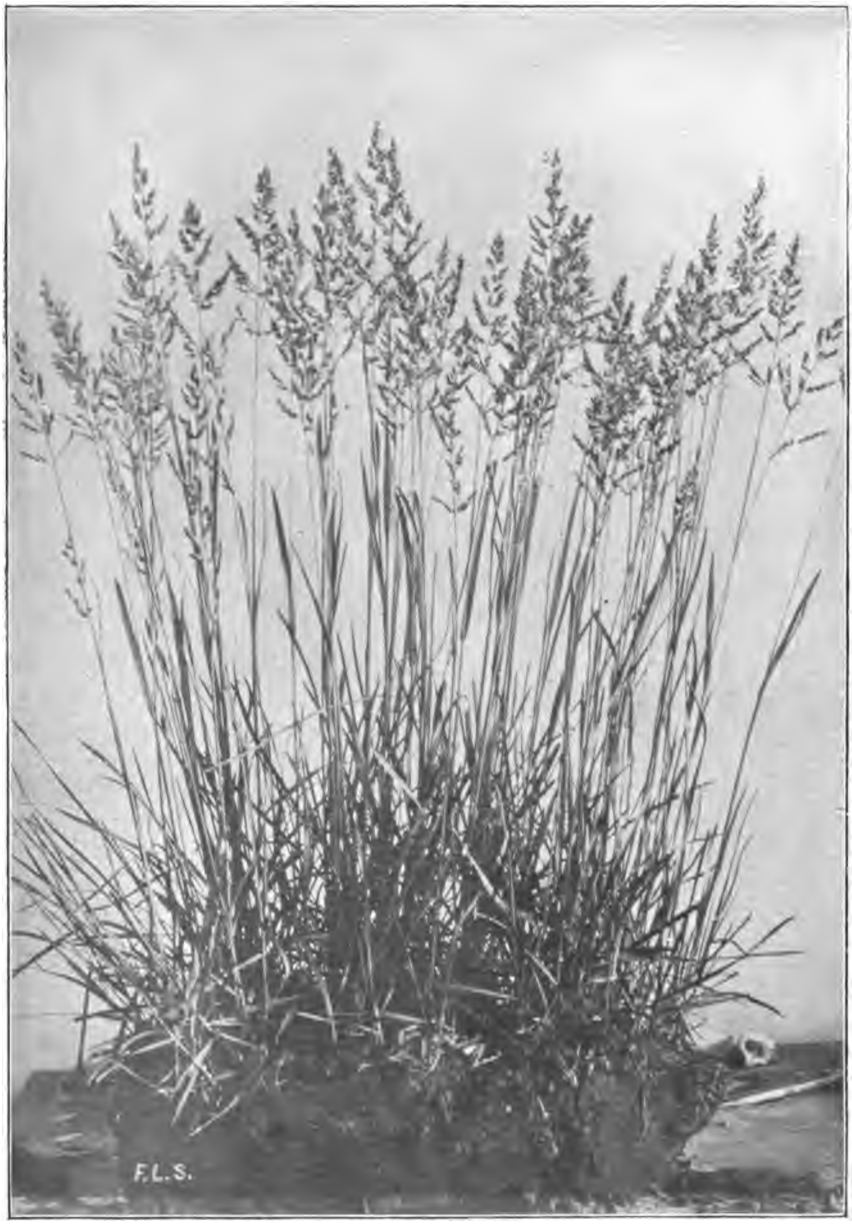
The question of the restoration of worn-out meadows and pasture lands is one of considerable importance in the Atlantic coast region, and particularly so in the New England States. Field studies of this question have been made by the Chief of the Division in Maine and Massachusetts, and experimental work looking toward the solution of this problem has been already arranged with the New Hampshire Experiment Station.

No separate publication giving the results of the field work done along the Atlantic coast has been issued. Much of the matter contained in Professor Scribner's Yearbook article for 1894 on "Grasses as sand and soil binders" was the result of this work, and also the article on "Sand-binding grasses" by the same author in the Yearbook for 1898. Bulletin No. 1 of the Division contains the results of Mr. Kearney's work in this region. An alphabetical and systematic list of the grasses and forage plants found is given with notes upon their habitat, habit of growth, distribution, abundance, and economic value.

GULF COAST.

CONDITIONS AND PROBLEMS.

The forage problems in the Gulf States are very numerous and varied. Their great importance was early recognized, and investigations commenced immediately after the organization of the Division. The long continued cultivation of single crops, especially cotton, had greatly impoverished the soil and led the more progressive planters to see the necessity of adopting a more diversified system of agriculture. Until quite recently a considerable portion of the hay consumed in the Gulf States was imported from other localities, and it was commonly believed that good pastures and meadows could not be made in that region. The great diversity of soils and climatic conditions, together with the presence of between 300 and 400 species of native grasses found growing in these States, naturally suggested the belief that the commonly accepted view regarding the forage possibilities of this region was erroneous. The great abundance of native grasses indicates that the South is naturally a grass producing country, and that considerable



TEXAS BLUE GRASS (POA ARACHNIFERA). A NATIVE SPECIES VALUABLE FOR THE GULF STATES.

Photographed from specimens grown at Washington, D. C., by F. Lamson-Scribner.

areas may be profitably devoted to meadow and pasture purposes. It was desirable at first to find what these native grasses were, the soil and climatic conditions under which they flourish, and the forage value of each, as well as the special purposes to which they were adapted. There was also the question of the introduction of various cultivated grasses and forage plants, and the testing of their adaptability and value.

The climate of this region is so favorable to the growth of grasses and forage plants that by proper succession pasture can be secured during the whole year, hence it was very desirable to ascertain what plants were best adapted to each season, and what the most profitable succession of seeding might be. Another question of great importance was the best method of improving and restoring the worn-out soils by the cultivation of the various leguminous forage plants, such as cowpeas, soy beans (Pl. III, fig. 1), and clovers, which, while producing large crops of hay or green forage, at the same time improve the chemical and mechanical condition of the soil and act as fertilizers.

WORK DONE.

An investigation of these various problems was begun by the Division immediately after its organization and has been continued every season since. The first work was done by Mr. Kearney, who visited various places in Alabama, Florida, and Georgia, besides the other points mentioned in referring to the field work done in the Atlantic coast region. A large collection of the grasses and forage plants of this region was made. Valuable information was secured by observation and careful field studies and also by interviews with various people familiar with the conditions and problems in question. The great value of the native hay and pasture grasses was definitely ascertained, as well as the possibilities in the way of introduction, cultivation, and more general use of the "tame" grasses and forage plants adapted to the various localities. The results of this field work were published in Bulletin No. 1 of this Division, entitled "Notes on the Grasses and Forage Plants of the Southeastern States." Notes on the most important grasses and forage plants for various purposes are given, also a complete list of all the grasses collected.

Prof. S. M. Tracy, formerly director of the Mississippi Agricultural Experiment Station, who from his long experience in the South and careful study of its forage problems was especially fitted for the work, was engaged to undertake an investigation of the forage conditions and questions of the Gulf States for this Division. He has done a large amount of field work in Georgia, Alabama, Mississippi, Louisiana, and eastern Texas, giving attention to all the various phases of the forage problems of the region. The results of this work were published as Bulletin No. 15 of this Division, entitled "A Report upon the Forage Plants and Forage Resources of the Gulf States." In this bulletin a rather thorough discussion is given of the various soil conditions, natural pastures, formation and care of pastures, temporary pastures, winter pastures, and also descriptions of the more important forage plants, with methods of cultivation and care of soils, and extended notes upon the more important hay and pasture plants of the region.

Professor Tracy, in speaking of the natural pastures, says:

> The natural forage plants vary as widely as the soils. Some adapt themselves to almost any situation and are quite general in their distributon, while others are extremely local. Some become more vigorous and abundant under frequent grazing, while others soon disappear with any change of surroundings.

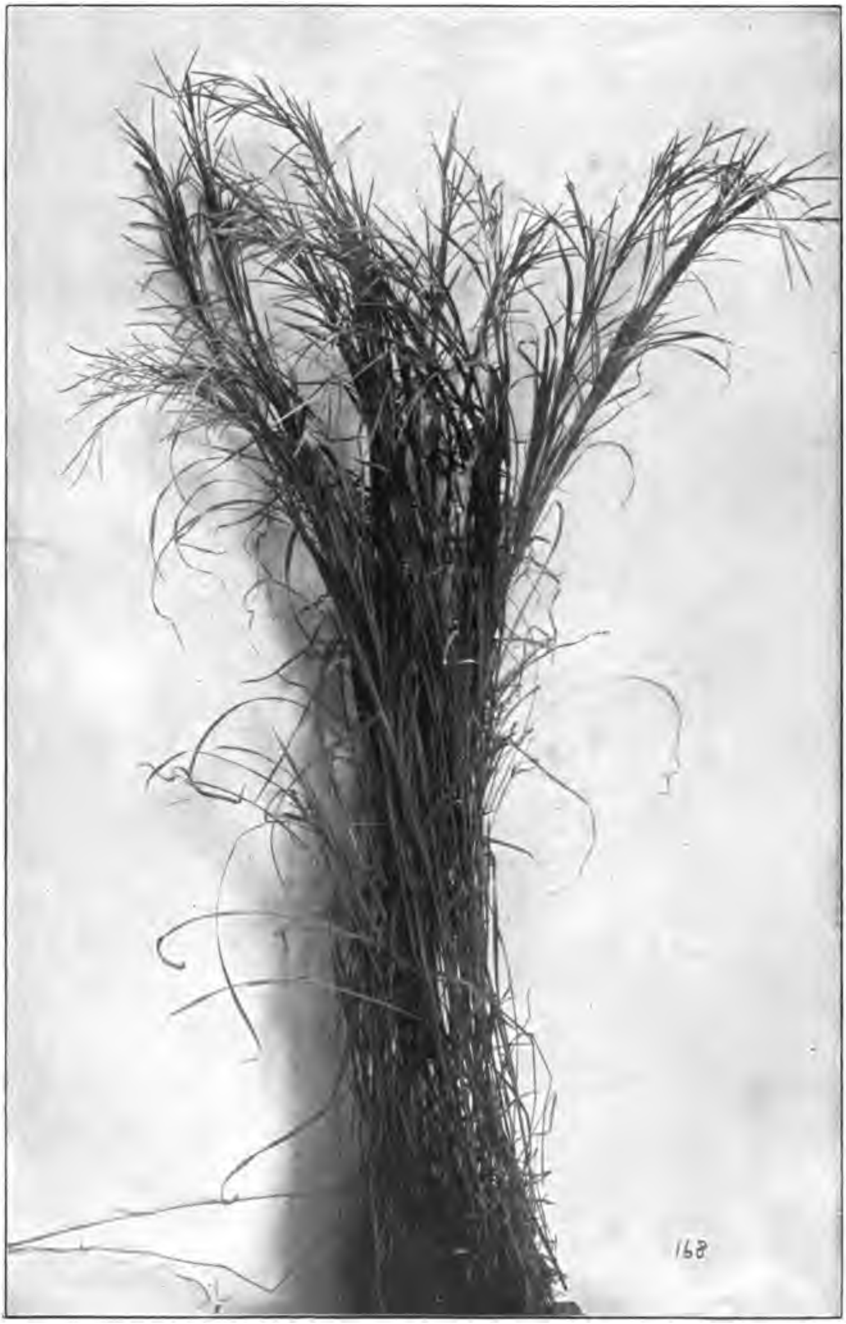
In regard to the formation of pastures, we may quote the following from the same report:

> With a climate favorable to almost continuous growth and with soil easily worked and promptly responding to good management it is not difficult to secure permanent pastures of the highest quality, and in order to obtain the best returns the same intelligent care must be used in their management as is given other portions of the farm. The best pastures are those which contain the greatest variety of plants yielding palatable food for stock. These plants should be such as make their greatest growth at different seasons, in order that there may be a continuous supply. A portion of them should be legumes, both for their superior fattening qualities and their effect upon the soil, and as large a proportion as possible should be perennials.

Carpet grass (*Paspalum compressum*) is excellent for pastures, especially on the thin sandy lands along the Gulf coast. It is a native and tends to spread and increase as the other and coarser grasses are destroyed by grazing. Its increase can be materially hastened, according to Professor Tracy, by mowing old pastures in July or August, when the grass is maturing seed, and scattering the hay thus made over the new field. For the more fertile lands Bermuda grass is most valuable (Pl. III, fig. 2). In speaking of the selection of varieties for pasture the following advice is given:

> For the whole of the Gulf States, excepting the sandy soils near the coast, Bermuda grass and Japan clover should be the foundation of every permanent pasture. On alluvial lands add redtop and alsike clover for the damper lands, with orchard grass, sweet clover, and bur clover for the drier lands. On the uplands, yellow loam, and clay sections, orchard grass and bur clover do well on the dry soils, while for wet places redtop, large water grass, and alsike clover should be added. For the black prairie regions, Texas blue grass (Pl. IV) and sweet clover are the best additions. On the light soils of the coast region, carpet grass, large water grass, giant beggar weed, and mutton cane largely replace the redtop and clover of the more Northern sections.

The question of the best crops for winter pastures is one of considerable importance in this region. It has been found that oats, rye and barley, and hairy vetch prove the most satisfactory. A mixture of turf oats and hairy vetch give especially good results. Rescue grass is also valuable for the same purpose. As a hay crop Bermuda



BIG BLUE-STEM (ANDROPOGON FURCATUS). A VALUABLE HAY AND PASTURE GRASS OF THE GREAT PLAINS.

From a photograph.

grass is most largely used. The sod, however, frequently becomes so matted that it should be disk harrowed in order to give the grass a fresh start. Of the annual hay plants, cowpeas are regarded as the most important and best. The large number of varieties, with the varying lengths of time required for growth, makes it possible to adapt them to various uses, so that they can be grown on land from which grain or any early crop has been harvested. The benefit which the soil derives from them is also of much importance. Crab grass (*Panicum sanguinale*) is also used very largely for hay. It is a volunteer crop, taking possession of fields upon which grain or similar crops have been grown, and produces a large amount of excellent hay, especially on the richer soils. The hay is of good quality, but needs considerable care in curing. German millet, Johnson grass, and red clover are also extensively cultivated for hay. Professor Tracy's report has been in great demand and has done much to increase the knowledge and interest of the farmers of the South in forage questions, and has also tended greatly toward the improvement of conditions.

Mr. C. R. Ball did field work two seasons in Louisiana, making especially large and important collections in the northern part of the State and investigating a region whose forage problems and conditions had not been before carefully studied. His collections and notes have added much to our knowledge of this region. The report of these investigations has not yet been published, but is in course of preparation and will soon be submitted in connection with a complete account of all the unpublished results of field work in the Gulf States.

Mr. Robert Combs, accompanied by Mr. Allen Scribner, spent several months during the summer of 1898 in northern, central, and western Florida, making a careful study of the forage resources of that State. Large portions of Florida have been found to be particularly well adapted to stock raising. Over large areas only a very small proportion of the land is under cultivation, so that stock have an abundant range in the woodlands, where there is an excellent supply of grass and other forage. The growing season being practically continuous, there is no lack of feed at any time during the year. For this reason very little attention has been given to cultivated forage plants. As the area of cultivated land increases, however, it will be found necessary to pay more attention to the establishment of permanent pastures and meadows, and also to the proper preservation and care of the more important native grasses and forage plants. It is very important that these questions should be carefully looked into and the proper steps taken before the ranges reach the serious condition of those in some other parts of the country, and it is hoped that the investigations which have been undertaken will result in the conservation and proper care of the natural forage of this State. A very large collection of the grasses and forage plants was secured, which has added very materially to our knowledge of the native species, their distribution, abundance, and value. The general results of these field studies have not yet been published, but the careful and valuable notes secured by Messrs. Combs and Scribner will be incorporated in the report on the Gulf States referred to above. Besides the above-mentioned field work in this region, Prof. F. Lamson-Scribner, Chief of the Division, has spent short periods at several points in Florida with especial reference to the question of sand-binding grasses of the region, and has also compiled, from the reports of the various field workers in the South, Farmer's Bulletin No. 102, "Southern Forage Plants," which treats in a simple and condensed manner the various forage problems and plants of the South, giving directions for formation and care of pastures, describing soiling and fodder crops, and giving a thorough account of the more important hay and pasture plants, with descriptions, illustrations, methods of cultivation, relative value, etc., of each.

THE GREAT PLAINS.

CONDITIONS AND PROBLEMS.

The Great Plains region, as limited for the purposes of the present discussion, extends from North Dakota south to Indian Territory and west to the foothills of eastern Colorado, Wyoming, and Montana. Though the area under consideration includes many million acres, yet the grasses and forage plants and climatic conditions are very similar throughout. The annual precipitation decreases over the whole region as one goes from the eastern border to the western. In the eastern portions of Kansas, Nebraska, and the Dakotas the annual precipitation averages from 25 to 30 inches. In the western portion of the Great Plains the rainfall is much less, the annual precipitation averaging from 10 to 20 inches. In the first half of the last century nearly all of this territory was included on the maps of the period under the title of the "Great American Desert." As the tide of immigration proceeded westward and the actual conditions became more definitely known, the imaginary borders of this desert were gradually pushed westward. The very fertile soils of eastern Kansas, Nebraska, and the Dakotas were found to produce abundant crops of wheat, corn, and other cereals, and rapid settlement and development of the country immediately followed. Attracted by the glowing accounts given by the early settlers, farmers from the East and immigrants from Europe continued to take up land and begin the cultivation of the soil. It was soon found by experience that while excellent crops were usually certain in the eastern borders of this region, the amount of moisture available during the season decreases so rapidly as you proceed westward that after passing the ninety-eighth meridian the production of corn and wheat is a matter

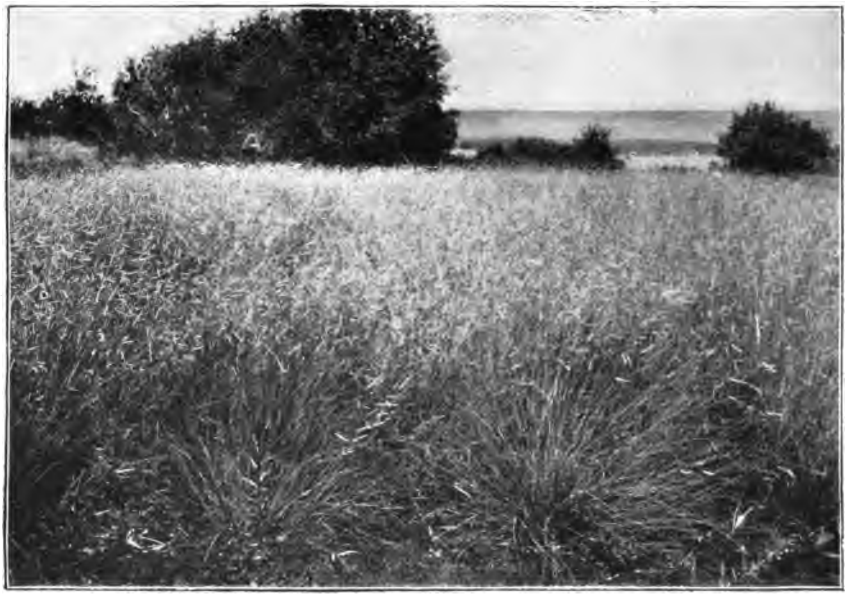


FIG. 1.—BLUE GRAMA (BOUTELOUA OLIGOSTACHYA), AS GROWN IN GRASS STATION AT WALLA WALLA, WASH.

From a photograph by A. B. Leckenby.

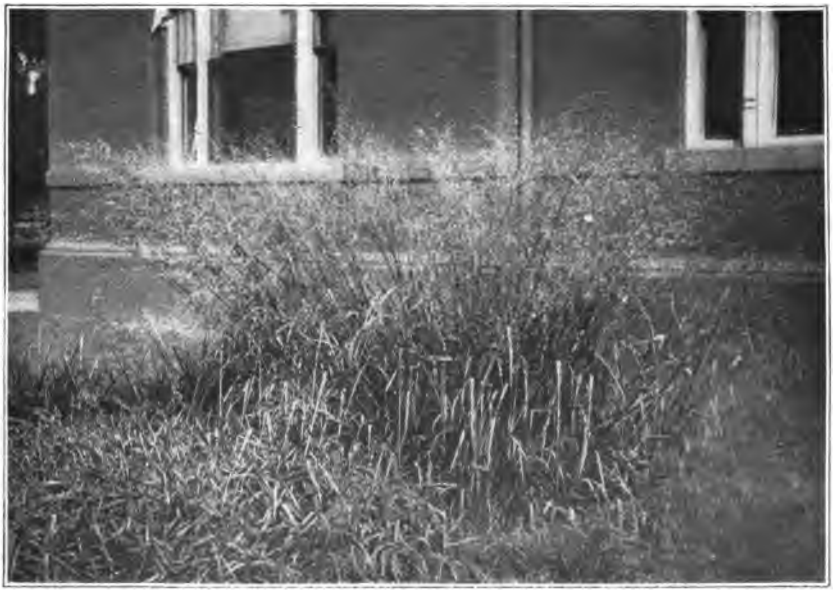


FIG. 2.—SWITCH GRASS (PANICUM VIRGATUM), AS GROWN IN THE GRASS GARDEN AT WASHINGTON, D. C.

From a photograph by C. L. Shear.

of considerable uncertainty. Nevertheless, influenced very often by unscrupulous persons who were willing to profit by the ignorance on the part of the home seeker of the actual conditions, people continued to take up these lands farther and farther west, in central and western Kansas and Nebraska, and break the virgin prairie sod with its luxuriant growth of native grasses, in hope of growing profitable crops of cereals. In this, however, they were destined to disappointment. Experience has shown that beyond the ninety-eighth meridian profitable crops of cereals are not produced oftener than one to three times in five years, so that farming without some means of irrigation can not be made a financial success.

Those who possessed sufficient acumen to appreciate these facts turned their attention at once to stock raising; but under the impression, apparently, that the forage resources of the country were inexhaustible, the pastures were overstocked and soon their carrying capacity was greatly lessened. When the more progressive stockmen began to realize that the native pastures were rapidly deteriorating and were threatened with destruction if the same treatment was longer continued, they began to make inquiries regarding the matter, wishing to find some remedy. Many of the people began to gradually realize that they had made a serious mistake in breaking these fine pasture and meadow lands in a hopeless endeavor to produce paying crops of wheat and corn. Thus they began to inquire as to what could be done to put down these cultivated lands to permanent meadows and pastures again. As the people turned their attention to stock raising and dairying, the question of drought-resistant soiling crops and other forage plants which might prove successful also naturally arose. It was in response to pressing demands for information along these various lines that the Division of Agrostology began immediately after its organization to undertake a thorough investigation of the different problems referred to.

WORK DONE.

Field work was commenced in this region by Mr. P. A. Rydberg and the writer. Studies and collections of the grasses and forage plants of the Platte River Valley were made at Valley, Central City, Kearney, and North Platte, Nebr. Collections of roots, seeds, and specimens of the more important native species were collected and careful notes made regarding the forage value, abundance, distribution, and importance of each. With the seeds and roots secured, plots in the grass garden on the Department grounds at Washington were made and an opportunity afforded for studying the behavior of these plants under cultivation. The results of this field work were published in Bulletin No. 5 of this Division, entitled "A Report on the Grasses and Forage Plants of the Rocky Mountain Region." The major portion of the report was devoted to investigations made in the Rocky Mountains, the work done in Nebraska being incidental.

Other field work in Nebraska has been done by Mr. C. J. Elmore, Dr. L. H. Pammel, Mr. T. A. Williams, late assistant agrostologist, Mr. J. G. Smith, who formerly occupied the same position in the Division, and also by the writer. Mr. Elmore did field work during a portion of the summer of 1896 in the southwestern part of the State, especially in Nemaha and Otoe counties. He devoted especial attention to the collection of sheaves of the native grasses and forage plants to be used for exhibition purposes by the Division and for distribution and exchange to various institutions, particularly the experiment stations. In this way a considerable number of specimens were added to the herbarium, and duplicates were also secured for distribution and exchange. During the same season Dr. L. H. Pammel, under commission from the Secretary of Agriculture, made a study of the forage conditions of western Iowa, Nebraska, and Colorado. The points at which work was done were as follows: Ames, Iowa; Omaha, Lincoln, Crete, Hastings, and McCook, in Nebraska, and also in northern and central Colorado in the vicinity of Fort Morgan, Greeley, Fort Collins, Golden, Denver, and Colorado Springs. A discussion of the Colorado work will be taken up in connection with the account of the work in the Rocky Mountain region. The results of Dr. Pammel's work were published in Bulletin No. 9, entitled, "Notes on the Grasses and Forage Plants of Iowa, Nebraska, and Colorado."

A quotation from Dr. Pammel's report will give an idea of the situation in Iowa:

> The forage question in central Iowa is very different now from what it was fifteen years ago. At that time considerable areas of unbroken sod still remained. Now the wild prairies have almost ceased to be a factor in the production of hay. The extensive prairies have given way to cultivated fields and pastures. Small unbroken areas occur here and there, but these are chiefly confined to the small drainage basins between hills, and exist largely because in times of considerable precipitation these depressions are too moist for proper cultivation. The Boyer and Maple valleys are noted for the large crops of wild hay annually produced. The same may be said of the rich alluvial flood plain of the Missouri. This plain varies from a few to 15 miles in width, the average being from 8 to 12. The hay crop constitutes one of the chief sources of revenue for the farmers of this region, and could be made much more important if they would follow a more rational system of cropping.
>
> The chief hay plants in central Iowa are timothy, redtop, blue grass, and red clover. The principal plants used in pastures are blue grass, white clover, redtop, and timothy. In the Boyer and Maple valleys and on the Missouri bottoms the wild grasses predominate. To a limited extent alfalfa meadows have been started in Carroll, Ida, and Woodbury counties. The loess hills skirting the Missouri bottoms are mostly cultivated, though unbroken wild meadows and pastures still remain. In the eastern portion of this district considerable corn fodder is used as forage, the amount used depending largely upon the condition of the pastures and meadows.
>
> Many other grasses have been tried with varying success. Orchard grass, naturalized in many places, is one of the most successful. Tall oat grass gives some promise.

AWNLESS BROME GRASS (BROMUS INERMIS), SHOWING PLAT OF THE GRASS GROWN IN THE UNITED STATES GRASS GARDEN, WASHINGTON, D. C.

This grass has proved a success throughout the northern portion of the Great Plains region. From a photograph by F. Lamson-Scribner.

Perennial rye grass is nearly worthless for this section of the State. Italian rye grass is unable to resist the cold of our winters and is a complete failure. Meadow foxtail (*Alopecurus pratensis*) does fairly well as an early grass when sown the season before, but is hardly adapted to this section. The most promising of the recently introduced grasses is smooth or hungarian brome. The short-awned brome has also been tried and is very promising. Rye and barley are often used as forage plants. German millet and hungarian grass find extended use some seasons. Broom-corn millet is frequently sown in northern and northwestern Iowa.

But one legume is generally grown and that is red clover. Mammoth or medium clover is often sown, but is much less common than the preceding. Alsike clover is becoming more common. Two sweet clovers are not infrequent; the white sweet clover is more abundant than the yellow. Crimson clover has been tried repeatedly, but is not adapted to Iowa conditions. It suffers much from drought in late summer, and from insect and fungous enemies.

Many native species of grasses occur, and they vary in quantity and quality in different sections of the State. The dominant grasses of central Iowa are little blue stem and big blue stem. Both of these species are frequently called blue joints. Several species of *Elymus* are abundant, as wild rye, on the prairies and meadows; Lyme grass on the flood plains of streams, and Dennett grass along the borders of woods. Other common grasses are: Indian beard grass, or bushy blue stem, in prairies and open woods; tall grama grass of the dry prairies and gravelly knolls; nodding fescue in woods; slender fescue in dry sterile soils; Short's fescue in low prairies, a most valuable species; switch grass in rather moist meadows; satin grass (*Muhlenbergia racemosa*, *M. diffusa*, *M. willdenowii*, and *M. mexicana*) in most soil of open woodlands and meadows; swamp chess in open woodlands; fowl meadow grass in low grounds along streams; wire grass and squirrel-tail grass (an introduced species) in meadows and waste places; blue joint, reed canary grass, common reed grass, and floating manna grass in marshy places and shallow water; large rush grass and bunch grass in dry prairies. In northwestern and western Iowa the above as well as some additional species occur. Among the latter are western wheat grass, bearded wheat grass, blue grama, slough grass, and big sand grass.

The most widely distributed of all the native leguminous plants is Canadian rattleweed (*Astragalus canadensis*), a thrifty, hardy, and vigorous species found in woods, low meadows, and prairies. It is eaten by stock, but becomes rather woody when old. Buffalo pea, or ground plum, is common on dry, sterile hills throughout the region and affords valuable forage. American vetch is one of the most valuable of the native legumes. It grows in the moist soil of low prairies and open woodlands. This vetch is well adapted to the conditions of western and northwestern Iowa, and does well under cultivation. The prairie clovers (*Petalostemon violaceus* Michx., and *P. candidus* Michx.) are common on the prairies everywhere, as also on the loess soils of western Iowa. These plants are seldom eaten by stock unless forage is scant. *Dalea alopecuroides* Willd. is common throughout the loess region and has been introduced farther eastward. Wild vetch, well known as a valuable forage plant of the Northwest, is indigenous to the loess, though not abundant except locally. It has been introduced into Boone County. Running buffalo clover (*Trifolium stoloniferum* Muhl.), a native, is considered a valuable forage plant by the farmers of western Iowa, and is worthy of a trial under cultivation. Mention should also be made of a loco plant (*Oxytropis lambertii* Pursh.) native to this region. Though often consumed by stock, no complaints have been made that it produces loco poisoning. Rattlebox (*Crotalaria sagittalis* L.) occurs in the more sandy bottoms of the Missouri River. Complaints have frequently been made of the trouble it causes when fed to horses. The disease it produces has been called "crotalism."

There are some serious obstacles in the way of maintaining the native meadows and pastures of Iowa. These may be classed under two heads—the overstocking of pastures and the growth of weeds. Many farmers attempt to raise more stock than their pastures will safely accommodate. The grasses can not endure the close grazing and excessive trampling to which they are subjected, and consequently they die out. Snow in this section of the State is usually blown from the open fields soon after falling, and hence can not be depended upon to protect the grass roots in pastures that have been too closely grazed. As a result of this, weedy annuals, like southern poverty grass, foxtail and squirrel-tail, spring up to take the place of the better perennial species, or the native ragweeds and verbenas spread and occupy the soil. All of these have become so plentiful that farmers remark on their more frequent occurrence now than in former years. Several rank-growing weeds are abundant in meadows and pastures of western Iowa. Sunflower and marsh elder find in the rich alluvial soil of the river bottoms a most congenial place for their development. They are especially troublesome on land that is often flooded during spring freshets. It may be that farmers of this region who rely chiefly on the hay crop will be obliged to introduce better turf-forming grasses, such as can resist the inroads of these weeds. From what I have seen of blue grass in this region it may prove a good grass for this purpose, and hungarian brome (*Bromus inermis*) may prove of even greater value. Snow-on-the-mountain (*Euphorbia marginata*), a well-known ornamental plant, is a serious pest in western and northwestern Iowa. Golden rods are often troublesome in pastures, especially *Solidago canadensis* and *S. rigida*. Stock will not eat them unless forced to do so, and when once well established in the pasture they are very difficult to eradicate.

In regard to Nebraska Dr. Pammel writes as follows:

Grazing is now and ever will be an important industry in the western half of the State. Although the grasses may not grow so luxuriantly season after season in Nebraska as in Iowa, the climate is more favorable for winter grazing than in the latter State, and there is a large number of valuable species of native forage plants.

Under the head of native grasses the great value of the more important species is referred to, the necessity of the careful conservation of the natural hay and grazing lands is urged, and the great injury resulting from overstocking is pointed out.

Mr. Williams's work in this region was carried on at different times since 1896 in eastern Nebraska, eastern, central, and western South Dakota, and also in southeastern North Dakota. Mr. Williams was particularly well fitted for attacking the forage problems here on account of his long residence in the region and the careful and special study which he had given the subject, especially while acting as botanist of the South Dakota Agricultural Experiment Station. The results of his field work in this region, as well as those of Mr. E. N. Wilcox, Dr. David Griffiths, and Mr. M. A. Brannon, were published in Bulletin No. 6, "Grasses and Forage Plants of the Dakotas." A general review was made of the farming and stock-raising regions of North and South Dakota, indicating the characteristics of the various natural areas and pointing out the special advantages of each for various agricultural and forage purposes. A description of the native grasses is given and the value of each for different purposes is pointed out. Attention is particularly called to the great value of the natural

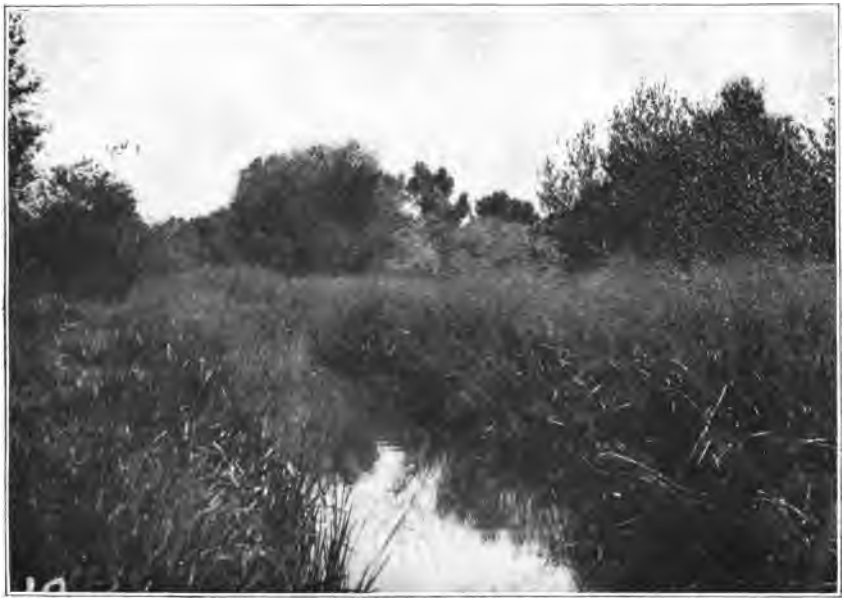


FIG. 1.—AMERICAN MANNA GRASS (PANICULARIA AMERICANA). A WET MEADOW GRASS.
From a photograph by C. L. Shear, taken near Antonito, Colo.

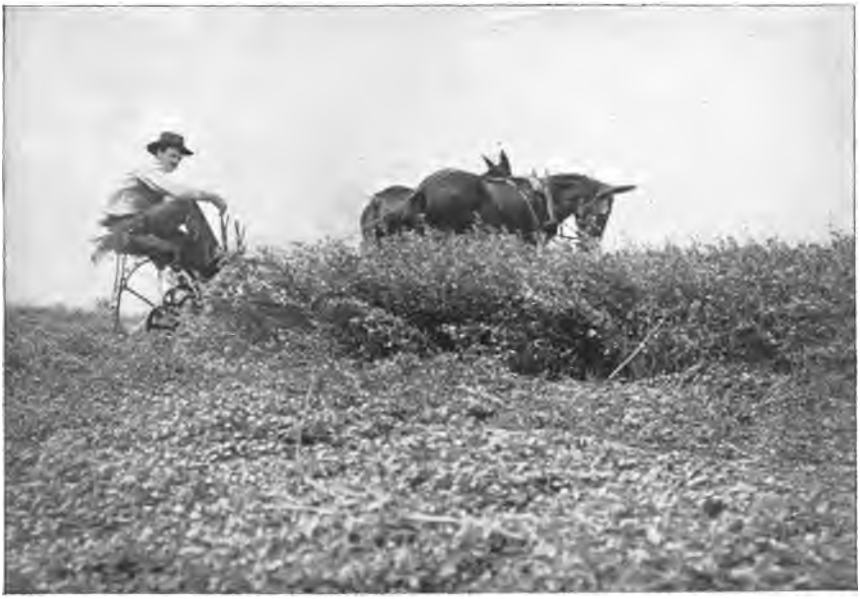


FIG. 2.—ALFALFA, BELLEFOURCHE, S. DAK., 1897.

orage and the importance of making every possible effort to pre[illegible] t. In speaking of overpasturing, he says:

> Overpasturing in times of drought is killing out many of the permanent grasses ere as well as elsewhere, and unless this practice is abandoned permanent injury ill result to this, one of the most important of the natural resources of the orthwest.

The irrigation problem is also discussed, and some of the possibilities es in the way of developing the water supply afforded by the artesian sin are spoken of. The great increase in the production of the tive grasses by a slightly increased supply of moisture is referred as follows:

> Experience has shown that many of the most valuable native grasses are very ich benefited by a judicious application of even a small amount of water. As a le there is sufficient rainfall to give the grasses a good start in the spring, and if ough water could be had to keep up a strong growth when the dry, hot weather es on an abundant forage crop would be assured.

Besides the general discussion of the results of field work covered the report there is given a complete list of the grasses and forage nts collected by the different field agents in this region, and also a t of the grasses and other forage plants of the Dakotas which are may be of importance as forage, giving notes on each species, inting out their particular characteristics and adaptation to special rposes, and also making suggestions regarding their treatment, [illegible] of saving, and [illegible] government [illegible] the [illegible] Mr. [illegible] results [illegible] the [illegible] further results [illegible] under the title "The Renewing of [illegible] pastures," in which [illegible] the native [illegible] lands, [illegible] and [illegible] recommending [illegible] the native [illegible] lands.

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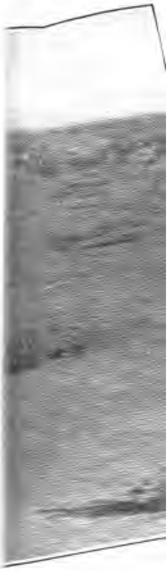


forage and the importance of making every possible effort to preserve it. In speaking of overpasturing, he says:

> Overpasturing in times of drought is killing out many of the permanent grasses here as well as elsewhere, and unless this practice is abandoned permanent injury will result to this, one of the most important of the natural resources of the Northwest.

The irrigation problem is also discussed, and some of the possibilities in the way of developing the water supply afforded by the artesian basin are spoken of. The great increase in the production of the native grasses by a slightly increased supply of moisture is referred to as follows:

> Experience has shown that many of the most valuable native grasses are very much benefited by a judicious application of even a small amount of water. As a rule there is sufficient rainfall to give the grasses a good start in the spring, and if enough water could be had to keep up a strong growth when the dry, hot weather comes on an abundant forage crop would be assured.

Besides the general discussion of the results of field work covered by the report there is given a complete list of the grasses and forage plants collected by the different field agents in this region, and also a list of the grasses and other forage plants of the Dakotas which are or may be of importance as forage, giving notes on each species, pointing out their particular characteristics and adaptation to special purposes, and also making suggestions regarding their treatment, method of sowing, and possible means of improvement. Besides the bulletin referred to, Mr. Williams published, in Circular No. 4 of the Division, further results of the field work in this region under the title of "The Renewing of Worn-out Native Prairie Pastures," in which attention was called to the rapidly deteriorating condition of the native pasture lands, at the same time pointing out the causes and results, and recommending methods for improving and renewing these native grazing lands.

The general effects of cultivation on native grasses and the great value of the same is pointed out, especially the beneficial results which are derived from disk harrowing and thus loosening the soil which has been greatly hardened by tramping of stock, so that the roots of the grasses may have an opportunity to develop. The question of manuring native pastures is also discussed, and the conclusion is as follows:

> Pastures which have been grazed closely for some time will be benefited by the application of a thin top dressing of well-rotted stable manure, followed by a thorough harrowing. It is doubtful if much is gained by putting coarse unrotted manure on the pasture. It can be used to better advantage on cultivated lands. Ashes generally have a beneficial effect on soils not too plentifully supplied with alkali. The collecting and sowing of seeds of the best native grasses, such as western wheat grass (*Agropyron occidentale*), slender wheat grass (*Agropyron tenerum*), wild rye grass

(*Elymus canadensis*), prairie June grass (*Kœleria cristata*), and the beard grasses (*Andropogon* spp.) is recommended, and an instance is cited of an excellent pasture of western wheat grass having been secured in this manner.

Small portions of Bulletin No. 12, by the same author, relate to this region, extracts from a report on work by Dr. Griffiths in western South Dakota, in 1897, being given.

Mr. Jared G. Smith, during his connection with the Division, did field work in Kansas, Nebraska, and South Dakota, besides having made a special study of the forage problems of the region during a long residence in Nebraska, a portion of which time he was connected with the agricultural experiment station of that State. The results of his work were embodied in an article published in the Year Book of the Department of Agriculture for 1895, entitled "Forage conditions of the prairie region." After a general consideration of the subject, in which the vast area of the region is referred to and the prevailing physical conditions and agricultural products mentioned, a discussion of the most profitable crops to be grown is considered.

The necessity for a more diversified system of agriculture is pointed out, and the greater profit to be derived by growing less corn and wheat and more grass and cattle is clearly shown. In this connection he says:

> It has been demonstrated, both by experiment and practice, that the farmer who sells beef, pork, and mutton, that he has produced from corn and grass raised and fed on the farm, makes more money per acre of his land and per dollar of his capital than the one who grows only wheat or corn or cotton.

The following quotation, which gives a comparison between the present and past condition of the prairies, is of interest:

> The prairies in their wild state were covered with the richest possible grass flora. There was no similar region that had so many useful species and so few poisonous or injurious ones. Almost any square mile of the whole extent of territory could furnish in one season 50 kinds of grasses and native forage plants, grasses that would make from 1½ to 2 tons of hay per acre as rich as that from an Old World meadow. It was a magnificent legacy to the rancher and the farmer. To the one it promised food for a million cattle; to the other it proved the golden possibilities of a soil that would bring forth bountiful harvests. But within the last thirty years all this has changed. We can no longer point to our broad prairies and say that the natural forage conditions here are the best in the world. Hardly an acre remains anywhere east of the ninety-seventh meridian that will still yield its ton and a half of prairie hay. There is hardly a square mile of prairie sod that will produce 30 kinds of native wild grasses and clovers per annum.

The superior qualities of the more important wild species is pointed out, especially their ability to endure drought, freezing, and flood. The futility of attempting to replace the native species by introduced ones is also clearly demonstrated. The beard grasses (*Andropogon furcatus* (Pl. V) and *A. nutans*) are described, their great value for hay and their nutritive qualities given. Other important species discussed are switch grass (*Panicum virgatum*), western wheat grass (*Agropyron*

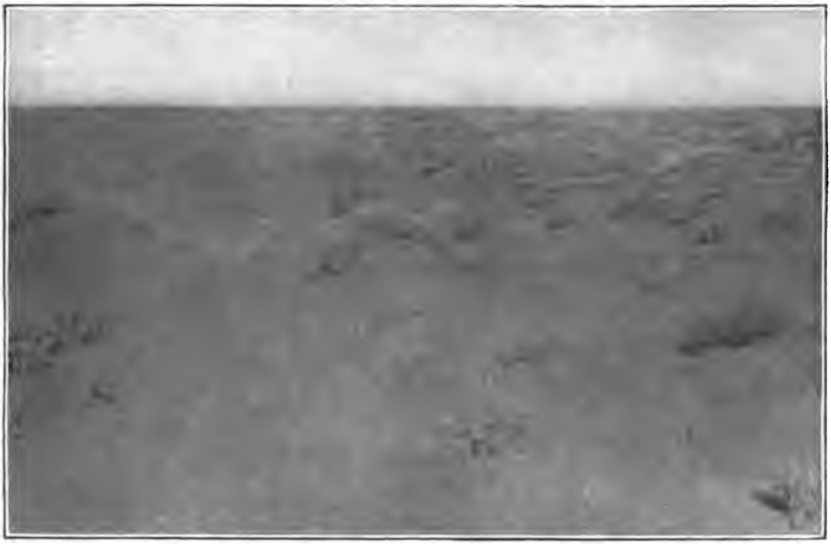


FIG. 1.—THE REAL RED DESERT, WYOMING.

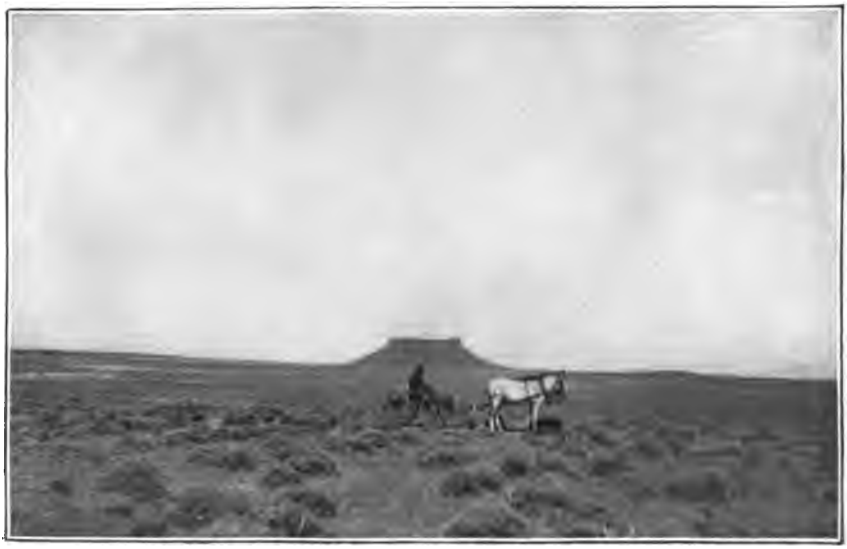


FIG. 2.—THE GREATER RED DESERT, WYOMING.

occidentale), the grama grasses (*Bouteloua curtipendula* and *B. oligostachya*), also buffalo grass (*Bulbilis dactyloides*), and prairie June grass (*Kœleria cristata*). Switch grass produces a very luxuriant growth, especially in the bottom lands and "draws" (Pl. VI, fig. 2). As it is inclined to get hard and woody when old, it should be cut before it has reached maturity. It is of most value for hay, being rather coarse for pasture. Its seeds are large and abundant and easily harvested. As it has been found to grow well under cultivation, it may be recommended especially for use in mixtures with other grasses. Western wheat grass is one of the best and most widely distributed of the native species in this region, especially for hay. It is everywhere highly esteemed and yields a good crop. The grama grasses are very abundant and important constituents of the upland prairies and meadows. The blue grama (*B. oligostachya*) is the most important one for pasture (Pl. VI, fig. 1). It forms a dense turf to the exclusion of other species, and it will endure a great amount of trampling, close grazing, and drought. This species, together with the buffalo grass (*Bulbilis dactyloides*), forms the greater percentage of the forage over a large part of this region. It is scarcely necessary to point out the great importance and nutritive value of buffalo grass. Its qualities are well known and thoroughly established. It forms an excellent dense turf of very fine leaves, and spreads by means of runners. It will survive great hardships, and is about the last species to succumb under excessive grazing. Unfortunately this grass can not be readily propagated from seed on account of its scarcity and the difficulty of collecting it. It can, however, be easily grown from roots and cuttings. The turf may be broken into fragments and planted in shallow furrows, in the same manner that Bermuda grass is planted in the South. It has also been found to adapt itself readily to conditions in moister climates and poorer soils. It has been grown very successfully for the past five years in the grass garden of the Department at Washington, D. C., where it forms an excellent turf, and endures the climatic conditions as well as in its native prairie home.

The prairie June grass (*Kœleria cristata*) is widely distributed through the whole prairie region, and is particularly valuable as a pasture grass on account of its early appearance in the spring. It is, however, a bunch grass in habit and does not form a continuous turf. It is much liked by stock and stands pasturing well. The seed is produced in good quantity and the grass is one quite well adapted to cultivation.

Mr. Smith gives the following advice regarding treatment of the native hay grasses:

> With such yearly yields and at such prices it will pay to improve the prairie meadows so that the product shall not decrease in amount or deteriorate in quality. The wild hay grasses should be permitted to reseed themselves, if not one year in three, at least one in four or five. Cutting the grass early in the season would help

to keep down the weeds. It is a matter of observation that the species of weeds which increase most rapidly in the hay fields are those that blossom and ripen their seeds before the hay is ready to cut. Their increase can be checked only by cutting them while they are in flower and thus preventing the seed from ripening. The intermingled mass of weeds and grass along the "sloughs" and "draws" or on the ground where old stacks have stood should be mowed and burned, or at least raked off the field. Otherwise these weed patches will grow in size from year to year and reduce the yield of hay.

Tame grasses, clovers, and soiling crops for the prairie region are also discussed in this paper. Some of the tame grasses and clovers have met with success in the eastern portion of this region where the rainfall affords a sufficient supply of moisture. Orchard grass and red clover mixed have proven successful in eastern Kansas and Nebraska. Tall meadow fescue has also met with fair success, although it is not so enduring as orchard grass. Alfalfa (Pl. VIII, fig. 2) is quite generally and successfully grown, but most of the introduced grasses and forage plants are not adapted to the conditions of drought prevailing over the greater portion of this region.

On account of the growing interest in dairying which is manifested at present in the prairie region, considerable attention has been given to soiling crops, the question of summer forage being an important one, as there is usually a period during the summer when pasture is scarce. Among the most promising plants for this purpose cowpeas and soy beans may be mentioned. Certain varieties of these plants have been grown with much success during the past few years in various places, especially in Kansas and Nebraska. Very little has been done with them in the Dakotas, as the season is usually too short for maturing most of the varieties. Corn, millet, hairy vetch, and field peas also make excellent green feed for milch cows and are to be recommended where they can be grown successfully. For hay and pasture awnless brome grass (*Bromus inermis*) has proven more successful than any other introduced grass tried (Pl. VII). Being a native of arid regions, it naturally does well in this region.

Under the heading "Improvement of the ranges" the question of overstocking and its results is discussed, and the necessity for discontinuing the practice is pointed out. The desirability of constructing artificial ponds or tanks for the conservation of the rainfall is shown to be of great importance, as it would obviate the necessity of cattle having to travel long distances for water, and thus trampling and packing the soil. As one means of improving the range lands, we may quote in conclusion from Mr. Smith's paper the following:

> Clearly, then, if the grazing quality of the ranges is to be improved, they must be so treated that the nutritious native species of grasses and forage plants can spread by means of the ripened seed. This can be accomplished by dividing the range up into separate pastures and grazing the different fields in rotation. There is a constant succession of species that ripen their seed from June to October, commencing with *Kœleria*, *Eatonia*, *Stipa*, and *Bulbilis* in June and July, and ending with *Andro-*

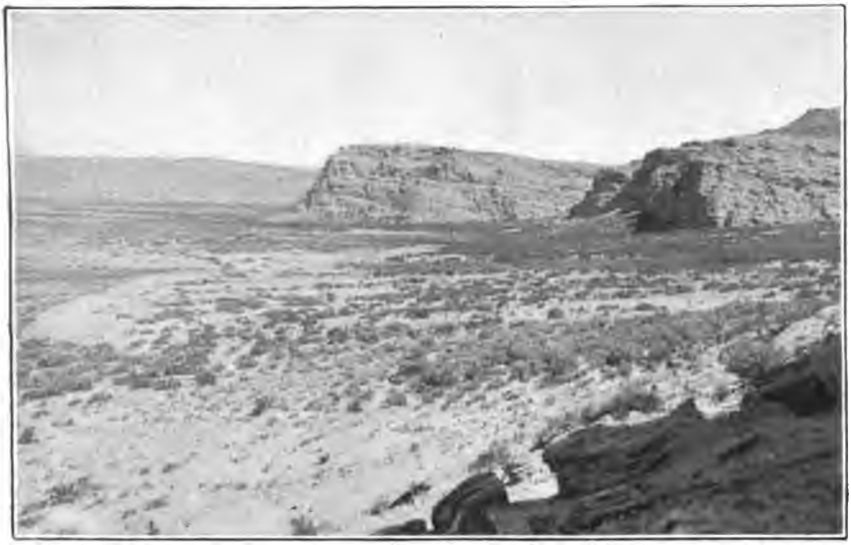


FIG. 1.—POINT OF ROCKS, BITTER CREEK VALLEY, WYOMING.

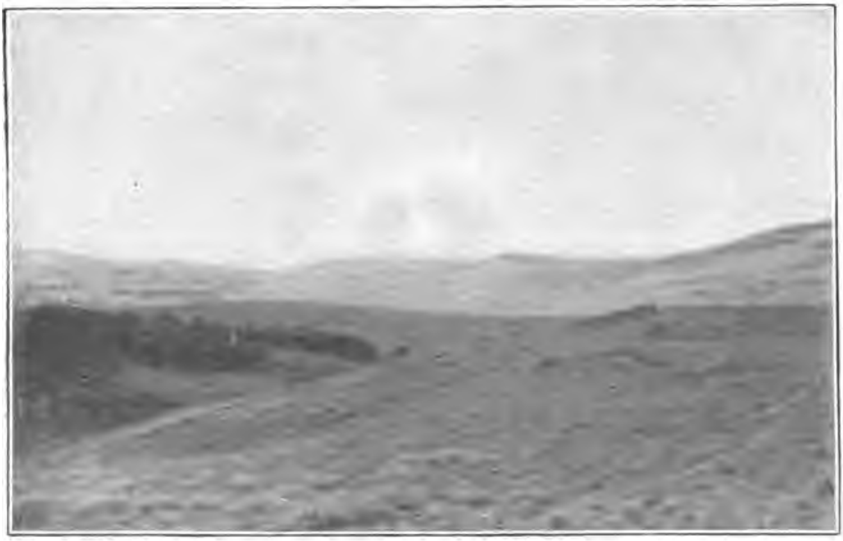


FIG. 2.—THE IDEAL SUMMER RANGE, WYOMING.

pogon, *Sporobolus*, and *Triodia* in October. If these grasses are killed out, their places will be taken by annuals of weedy proclivities, such as the numerous species of *Eragrostis* and *Aristida*, which are neither lasting nor nutritious—grasses that spring up with the early summer rains, ripen an abundance of seed, and die.

ROCKY MOUNTAIN REGION.

CONDITIONS AND PROBLEMS.

Under this heading the work in Colorado, Utah, Wyoming, and Montana will be discussed. The physiographic and climatic conditions throughout this region are extremely varied, and consequently the forage problems are very numerous. The climatic conditions naturally depend largely upon the contour of the country. In the higher altitudes of the extensive mountain regions there is usually sufficient moisture, either in the form of rain or snow; hence the mountain pastures and meadows do not suffer much from drought. In the foothills, broad valleys, and more or less elevated bench lands the conditions are more unfavorable for the development of vegetation, as the amount of available moisture is much less. The flood plains and bottom lands along the rivers and larger streams have been settled and placed under irrigation and produce abundant crops. The greater portion of the unirrigated areas of this region is used for grazing. The problems met with here are as numerous and varied as the soils and climatic conditions, and their great importance can be appreciated when it is known that the greater part of this country will probably never be profitably used for other than grazing and forestry purposes on account of the physical features and unfavorable climatic conditions. The importance of the problems here was early recognized and steps taken toward a thorough investigation of them. The range lands, owing to injurious treatment, were rapidly deteriorating and their carrying capacity was much lessened. With the rapid increase in population and number of stock there arose a demand for hay for winter feed. There was also the question of forage crops that might be successfully cultivated on the arid soils, which were so situated as to make irrigation impossible. These extensive areas of alkali soils presented various questions as to the possibilities of growing forage plants. The injurious methods of irrigation had also resulted in the, at least temporary, ruin by seepage of some of the best of the valley lands. The various subalpine meadows were also in need of improvement. The scanty amount of available knowledge of the forage and actual condition of affairs over the greater portion of this region made it particularly desirable to begin a thorough investigation of the various problems presenting themselves. The inaccessibility of a large part of the country made field work here more difficult and expensive than in many other regions, as the work could only be successfully carried on by extended trips overland.

WORK DONE.

The work here was commenced in the season of 1895 by Mr. P. A. Rydberg and the writer. Only a general survey of the region was attempted, as it was considered desirable to first secure a knowledge of the main features of the conditions and problems as a basis for more thorough work. During the investigations the following points were visited, beside those in Nebraska which have been referred to in discussing the Great Plains region: Green River, Wyoming; Beaver Canyon, Idaho; Lima, Red Rock, Dillon, Melrose, Silver Bow, Deer Lodge, Garrison, Helena, Townsend, Logan, Manhattan, Bozeman, and Butte, Mont.; Logan and Echo, Utah; Denver, Golden, Idaho Springs, Georgetown, Silver Plume, Boulder, and La Salle, Colo. The results of this work were published in Bulletin No. 5, "A Report upon the Grasses and Forage Plants of the Rocky Mountain Region." The following lines of work were given especial attention: First, making a collection of all the grasses and forage plants met with and taking notes regarding their abundance, distribution, forage value, and probable adaptability to cultivation; second, an examination of the meadows and ranges as to their present condition and the securing of all possible information regarding their former condition. A large collection of seeds, sheaves, and roots was also made. The number of specimens secured was over 4,000, among which were grasses which had not before been collected or described.

Under the head of "Field notes and general observations" the various places visited were discussed and the more important grasses mentioned. Under the head of "Grasses deserving special mention" a list was given of the most important native species, with notes on their characteristics and the particular uses to which they were best adapted. The great importance of many of these species was indicated and the desirability of introducing them into cultivation was pointed out.

During the same season Mr. E. R. Chase did some field work for the Division in Utah, at Brigham City and vicinity. He gave special attention to the possibilities in the way of cultivating the native grasses and forage plants and the collection of seeds and sheaves of the more important species.

In 1896 the work in this region was extended and vigorously pushed. Mr. P. A. Rydberg continued the work in Montana. Equipping himself with a camping outfit at Bozeman, in the southern part of the State, he made an extended trip overland through the mountain regions to the northward, making an especially careful study of the forage resources of the region. He made a large collection of specimens and seeds, with notes on the conditions and problems.

It is only by the careful work which can be done by this method of traveling that a thorough study can be made of the actual condition

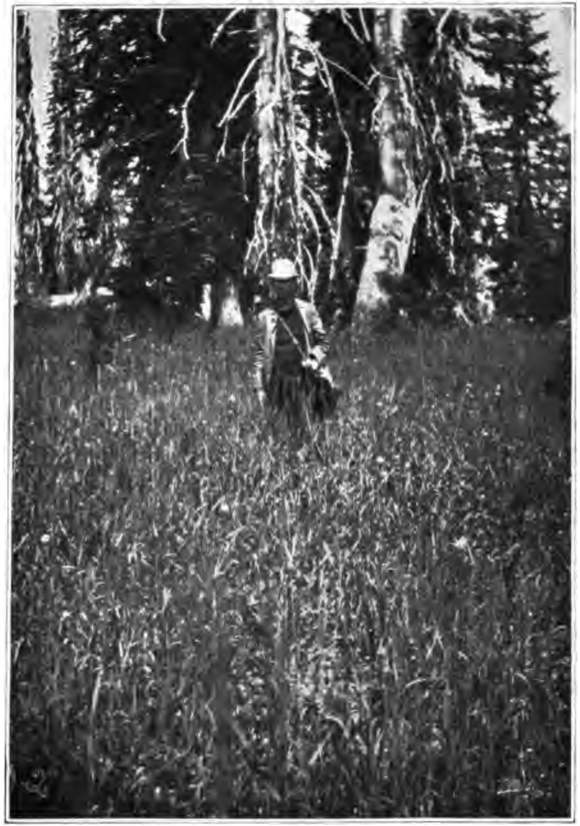


FIG. 1.—MOUNTAIN RYE GRASS (ELYMUS GLAUCUS). AN EXCELLENT GRASS ADAPTED TO HIGH ALTITUDES.

From a photograph by C. L. Shear, taken at Buffalo Pass, Colorado, altitude, 10,000 feet.

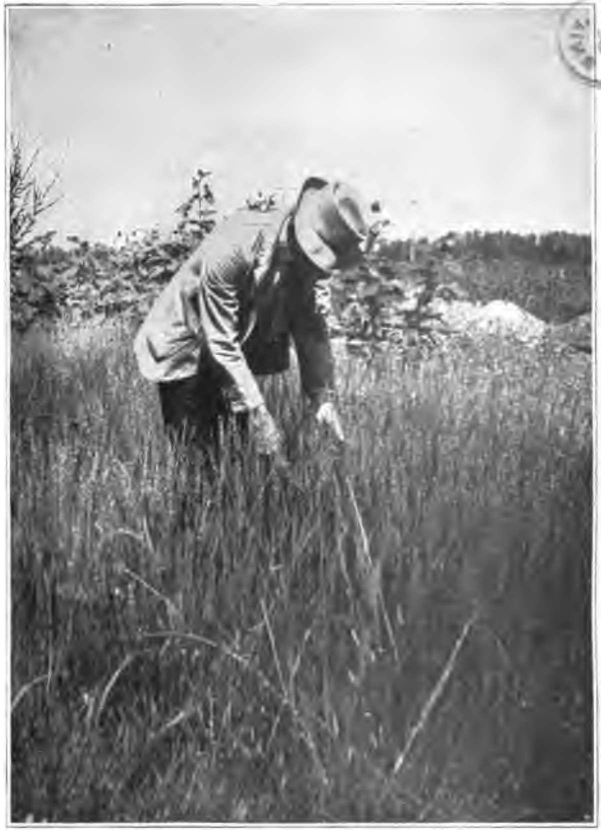


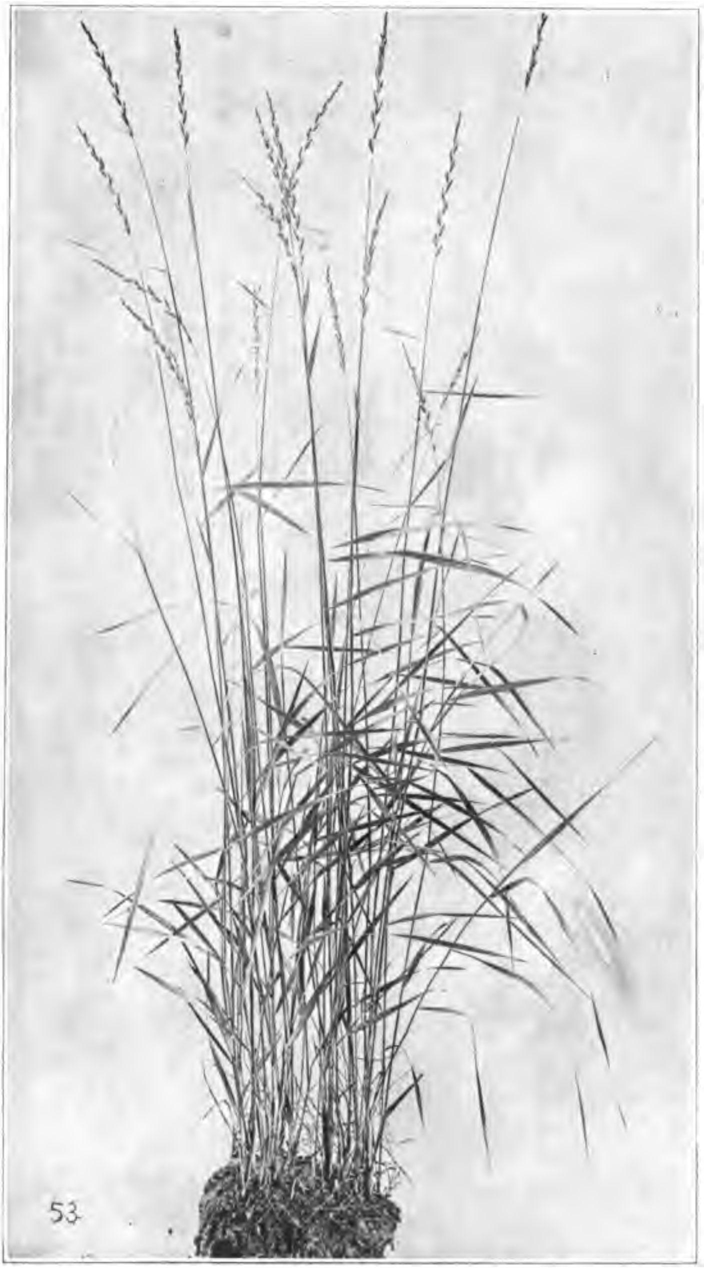
FIG. 2.—SIDE OATS GRAMA (BOUTELOUA CURTIPENDULA). AN IMPORTANT HAY AND PASTURE GRASS OF THE GREAT PLAINS.

From a photograph by C. L. Shear, near Rocky Ford, Colo.

of the various portions of the range and its forage resources. In this way the field worker comes into direct contact also with the ranchers and stockmen and secures at first hand information regarding previous conditions and treatment of the ranges, and also the views of these persons as to the best method of meeting the problems presented. During the same season Mr. F. E. Clements and the writer spent nearly three months working in Colorado. As the results of this work have never been published, it may be best to give an outline of the work done and the results accomplished. Work was commenced in the Pike's Peak region in the vicinity of Colorado Springs. The forage plants of the region were collected and notes taken regarding their abundance and value. The range lands on the mesa and in the mountains were investigated. As a result of the prevailing arid conditions and overstocking, the pastures on the mesa and in the foothills are very poor. The most important grasses are the grama grasses (*Bouteloua oligostachya* and *B. hirsuta*), the first being the most abundant and important, as it is about the last to succumb to harsh treatment. As the better grasses are destroyed their places are largely occupied by species of less value and of weedy proclivities, such as little drop seed (*Sporobolus depauperatus*) and the triple awns (*Aristida* spp.). Some areas of excellent mountain pastures are to be found in the higher altitudes, especially in the vicinity of Seven Lakes. The bulk of the forage here consists of sheep's fescue (*Festuca ovina*), with occasional small areas of tufted hair grass (*Deschampsia cæspitosa*) and alpine timothy (*Phleum alpinum*). In the wetter portions about the lakes species of *Carex* and *Eleocharis* predominate. The greater portion of the timbered areas and open mountain sides in this vicinity produce very little forage.

The next point visited was Walsenburg. The soil on the plains here is rather sandy. The whole region was formerly an immense cattle range, which has been largely abandoned during recent years. Here as elsewhere the prevailing and most important pasture grass is the blue grama. It is very thin and scattered, however, owing to the overstocking of the pastures, which has been carried on until recently. If given proper opportunity to recover, there is little doubt but that this grass will rapidly spread and largely restore the range. A considerable number of other species occur in the thickets along the borders of streams and cultivated lands, but not in sufficient quantity to be of much economic importance. In the vicinity of the alkali lakes near Walsenburg, alkali meadow grass (*Puccinella airoides*) is rather abundant, and furnishes considerable forage, though it is not so well liked by stock as many other grasses. It possesses, however, alkali resistant qualities, which enable it to grow in soils which better grasses can not endure. The work was continued up the valley of the Cuchara to La Veta, where there are some excellent meadow lands. A good opportunity was afforded here to note the effect of a slight increase in the supply of moisture upon the native grasses, as many of the native meadows here are under irrigation. Several of the wheat grasses and rye grasses (*Agropyron* and *Elymus* spp.) grow luxuriantly; also the gramas and the manna grasses (*Bouteloua* and *Panicularia* spp.) (Pl. VIII, fig. 1). Continuing westward, the mountain range lands in the vicinity of Veta Pass were visited. As overstocking has not been carried on here, at least to any great extent, in recent years, the pasture lands are in very fair condition. On the open mountain slopes several bunch grasses are quite abundant, especially the fescues. One species in particular, Thurber's fescue (*Festuca thurberi*), grows very luxuriantly here. This, besides its value for pasture, gives great promise for cultivation. A small area of it has been grown in the grass garden at Washington, and it has shown itself readily adapted to cultivation. Efforts have been made to secure a sufficient quantity of seed to experiment with more extensively, and it may ultimately prove superior to the meadow fescues for cultivation, especially in the more arid regions. Western brome (*Bromus pumpellianus*) is also found in considerable quantity in Veta Pass and vicinity. Species of blue grass, wheat grass, and rye grass also occur frequently, and furnish excellent forage.

The San Luis Valley was next visited. The greater portion of this valley is a great arid plain, covered over the major part with sage brush (*Artemisia* sp.) and buck brush (*Bigelovia* spp.). Some portions are irrigated from artesian wells as well as by water taken from the Rio Grande. There are extensive alkali areas on which salt grass (*Distichlis spicata*) is very abundant. Over the greater portion of the range land the grasses are few and scattered. Slender wheat grass (*Agropyron tenerum*) was originally described and named from specimens collected in this valley in the vicinity of Garland, and it is a species of considerable economic importance here as elsewhere in Colorado. After studies and collections had been made at Garland, Alamosa, and Villa Grove, the mountain meadows and pastures about Marshall Pass were visited. The condition of the range here, as well as of the forage plants, is very similar to that of Veta Pass. The range here has apparently not been overstocked to any great extent, and its carrying capacity therefore not materially diminished. The comparative inaccessibility of these higher mountain pastures prevents their being ranged over so extensively as the more accessible range lands of the lower altitudes. Many valuable species of native grasses occur here and grow in great luxuriance, especially in the immediate vicinity of the low lands and wet meadows. Blue grasses, bromes, rye grasses, and wheat grasses predominate. Passing from Marshall Pass to the Gunnison Valley, considerable areas of native meadow lands are found along the streams, and these produce abundant crops



WESTERN WHEAT GRASS (AGROPYRON OCCIDENTALE). A VERY IMPORTANT NATIVE HAY AND PASTURE GRASS IN THE GREAT PLAINS AND ROCKY MOUNTAIN REGIONS.

of excellent hay. The mesas, foothills, and mountain slopes, however, are very sparsely covered with forage plants. After short stops at Salida and Canyon City, a trip was made to the Wet Mountain Valley. This region has been favorably known for many years on account of the quantity and quality of native hay produced. The meadows here, by long continued cutting, have become far less productive than formerly. Native meadows extend along Grape Creek for 10 or 15 miles, averaging in width from 1 to 2 miles. The quality of the hay produced is somewhat inferior on account of the presence of sedges, rushes, and similar plants which occupy the wetter portion of the meadows. Judicious draining of certain portions of these meadows and permitting the grasses to seed themselves occasionally would no doubt greatly improve both the quantity and quality of the product. Work was also done in the vicinity of Twin Lakes, where there are considerable areas of swampy meadow lands producing chiefly sedges. Passing over the mountains into the Blue River Valley, an examination of the alpine and subalpine meadows and pastures was made on Mount Bartlett, near Robinson. On the slopes of the higher mountains in this vicinity, above timber line, quite extensive areas of excellent pasture lands occur. These are chiefly used for sheep grazing. Sedges, short-leafed fescue (*Festuca brachyphylla*) and blue grasses furnish most of the grass forage. There are quite a number of other native herbaceous plants, however, which furnish a considerable amount of feed and are relished by sheep. The sheep grazing here does not seem to be carried on in such a manner as to do injury to the range or to the timber land. The sheep are fed here only a short portion of the year, and then not usually in large enough numbers to do any serious harm.

Further study of forage conditions was made at Dillon, Breckenridge, and Como, the latter place being situated in the northwestern portion of South Park. South Park has long been noted in Denver and other local markets for the excellent quality of its wild hay. In the lowlands of the park there are extensive wild hay meadows quite similar to those of Wet Mountain Valley. A considerable portion of the hay produced here consists of *Juncus balticus*. This is generally called "wire grass," though of course it is not a true grass at all. It is very highly prized for hay, and brings a better price on the Denver market than any other hay. As a result of the work in this portion of Colorado, a very large and valuable collection of the grasses and forage plants of the region was secured, some of which proved to be new. A knowledge of the exact conditions of the different range and meadow lands was ascertained, and the relative value of the different grasses and forage plants determined. Seeds, roots, and sheaves of the more important grasses were secured. Fortunately most of the meadows and range lands of the areas just described have not been so badly injured but that a period of rest would largely restore them to their original vigor and carrying capacity.

Prof. L. H. Pammel also did work in central and northern Colorado during the summer of 1896. His investigations were carried on in the vicinity of Fort Morgan, Greely, Fort Collins, Golden, Denver, and Colorado Springs. The results were published in Bulletin No. 9 of this Division, which has already been referred to in connection with the field work in Nebraska and Iowa. In this report the forage plants and conditions of this portion of Colorado are discussed. The chemical composition of a number of the most important native species is given, showing that they compare very favorably with the cultivated grasses. In referring to the importance of improving the native species for cultivation, we may quote the following:

> If by selection from the native grasses an improved form of western wheat grass or grama grass can be introduced into the semiarid regions, it will give greater returns than any of those already there, the live stock industry will be put on a better basis, and its success assured.

In 1897 Prof. Aven Nelson, of the Wyoming Agricultural Experiment Station, made a special study of the Red Desert of southern Wyoming and its forage resources. This region covers more than 11,000 square miles. It is a high, undulating plain or plateau, averaging from 6,000 to 7,000 feet elevation (Pl. IX). The water supply is so limited and of such a poor quality that very little of the land can be used for cultivation, consequently it is distinctly a stock region. During the summer season it affords very little in the way of forage, hence it is used almost entirely as a winter range. Professor Nelson says:

> From the 1st of June to the 1st of November the region is practically devoid of stock of all kinds. With the coming of the snows the herds and flocks are worked back into the desert from the summer pastures in the hills and mountains. Through the winter and spring months thousands of head feed upon this rough forage, snowdrifts furnishing the water for all. The sheep herder in his wagon, also dependent upon the snows, guides his flock from district to district as new pasturage is needed. By the time the stock is taken to the summer range the desert is barren indeed. Grasses, sagebrush, salt sage, white sage, rabbit brush, and even cedar, have been grazed so closely that every edible sprig is gone.

In the report from which the above quotation is made (Bulletin No. 13, Division of Agrostology, "The Red Desert of Wyoming and its Forage Resources") Professor Nelson gives a thorough description of the forage problems of this interesting region, both from a scientific and economic standpoint. The topography, geology, soil, and climate are discussed. The soil over the greater portion of the desert is nearly all impregnated with alkali. Analyses of samples of soil taken from various localities show from 0.12 per cent to 7.20 per cent of water-soluble salts. This does not, however, represent the largest amounts

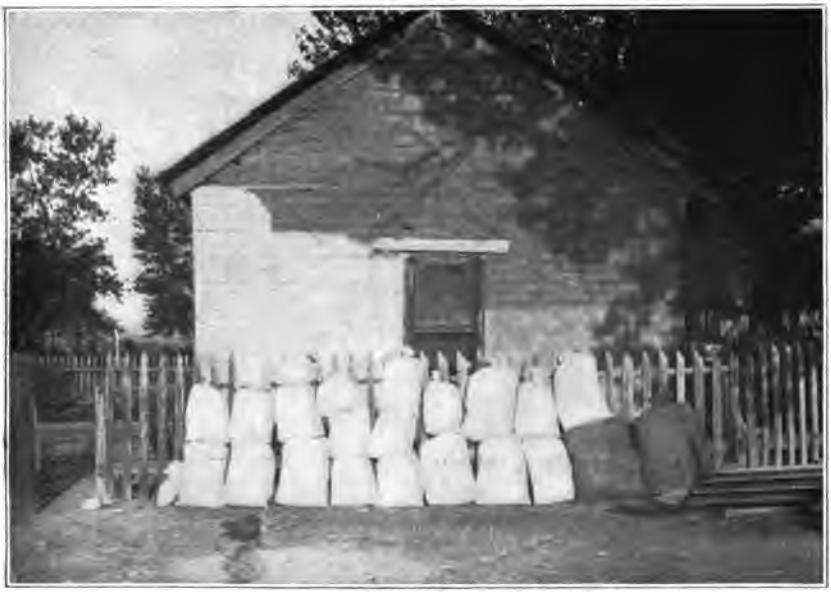


FIG. 1.—SEED OF NATIVE GRASSES, THE RESULT OF TWO DAYS' COLLECTING NEAR CHICO, COLO.

From a photograph by C. L. Shear.

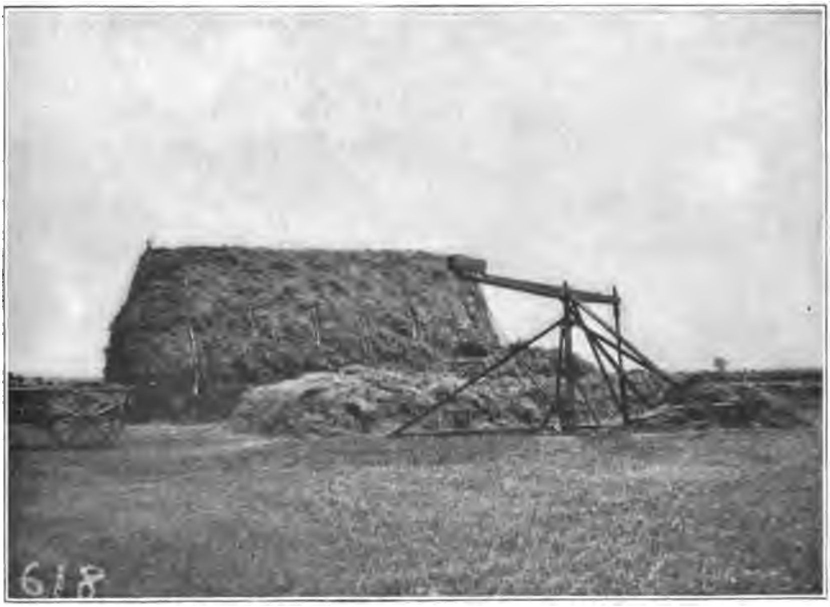


FIG. 2.—STACK OF WILD HAY, SHOWING METHOD OF STACKING.

From a photograph by C. L. Shear, near Chico, Colo.

of alkali that are found. In the bed of a dry pond a species of *Scirpus* was found growing where the surface soil contained more than 60 per cent of soluble salts. Very little of this alkali is what is known as "black alkali," the greater portion of it being what is called "white alkali," of which sodium sulphate is the chief constituent. The bulk of the forage is furnished by saltbushes, sagebrushes, and other plants than grasses. Wheat grasses (*Agropyron* spp.) are most abundant. The amount of alkali in the soil renders the growth of many grasses impossible.

Regarding the present condition of the ranges of this region as compared with the past, we may quote the following:

> According to the most reliable sheep men, the same areas that twenty years ago would only support one sheep will now support from three to five. This they attribute to the gain in the strength of the soil, due to accumulating manure. It seems probable that a more potent factor is found in the following: The vegetation chiefly depended upon for forage is composed of the large number of small shrubs of many kinds previously mentioned. Cutting down to the ground of such vegetation enormously increases the number of annual shoots. From winter to winter this shrubby vegetation has been browsed down closer and closer to the woody bases of the plants, until now the tender annual shoots are produced in much greater abundance. The effectiveness of this browsing is, of course, dependent upon the region being used as a winter pasture only, giving time for growth and recovery each summer.

It will be noted that the improvement which has taken place here affects the shrubby forage plants and not the grasses, and that this improvement is dependent upon the resting of the range land during the greater portion of the growing season. Regarding the native grasses the author says:

> The native grasses also are worthy of trial. The writer has seen wonderful results from seeding the ground to some of these, especially the wheat grasses, and this, too, where the water used for irrigation was far from the best and the ground strong with alkali. Furthermore, the increase in the water supply is not quite hopeless. The region contains many natural basins in which, by the expenditure of a little labor in the construction of dams, much of the water from the accumulated winter snowdrifts might be saved for use later in the season.

In addition to the subjects already mentioned, descriptions and notes regarding the forage value of the various saltbushes (*Atriplex* spp.) and sagebrushes (*Artemisia* spp.) are given. There is little doubt that some of these plants will prove worthy of cultivation. Seeds of many of them have already been secured and experiments commenced to demonstrate their value under cultivation in arid and alkali soils. Descriptions of the grasses of the range are also given, with full notes regarding their value and the best methods of increasing their production. Besides the Red Desert proper, an investigation was also made of the foothills and mountains which furnish grazing for stock during the summer season (Pl. X, fig. 2). The forage here consists much more largely of grasses, the most abundant and valuable of which are discussed. Besides a complete list of the forage plants of the summer range, a systematic list, with notes on all the plants collected in the Red Desert, is given.

Other work in the Rocky Mountain region was carried on in 1897 in southwestern Colorado by the writer, assisted by Mr. A. Selig, and by Messrs. Williams and Griffiths in the Big Horn Mountains of Wyoming, and in southern and western Montana. The results of this field work, as well as of all that upon which nothing had been published previous to 1898, were combined by Mr. Williams in Bulletin No. 12 of this Division, under the title "A Report upon the Grasses and Forage Plants and Forage Conditions of the Eastern Rocky Mountain Region." From the author's own extensive work in this region and from the reports and work of field agents it was possible to obtain a better grasp of the forage conditions and problems of this region than had been done heretofore. In the introduction the great importance of the stock-raising industry is referred to and the growth of interest in the various problems connected with it. Besides the information derived from field work undertaken by employees of this Division, much was secured from prominent stockmen, farmers, and others familiar with the problems by a circular letter of inquiry. Answers to this were received from about six hundred persons. These answers show how varied are the forage problems of the region. At one place it is early spring forage that is most needed, at another there is a lack of winter forage, and at another it may be summer feed. Under the heading of "General topographical features of the region," the great amount of variation in the physical character of the country is pointed out. A description of the soil follows, and also of the water supply. Under the heading of "Present aspect of the forage problem," the important questions which present themselves are discussed, and the causes and conditions which have led to the present troubles are pointed out. Unfavorable seasons and the destruction of the forage by over-stocking made it necessary for stockmen to provide feed in order to carry the herds safely through the winter. Many, however, did not attempt anything in this direction until compelled to do so by very serious losses. Thus one of the great needs of this region is a hay plant that will endure the arid conditions and alkali soils and produce profitable crops. Of course in localities where there are facilities for irrigation alfalfa can be very successfully grown. But alfalfa, to be used to the best advantage, should be supplemented by some other hay. Alfalfa, also, is restricted to certain altitudes. In Montana it can not be successfully grown at a greater altitude than 4,500 or 5,000 feet, and since about one-half of the area of the State lies above this limit it will be seen that some other hay plant is needed to meet the requirements of a large portion of this State. As we go farther south, the limit of successful growth

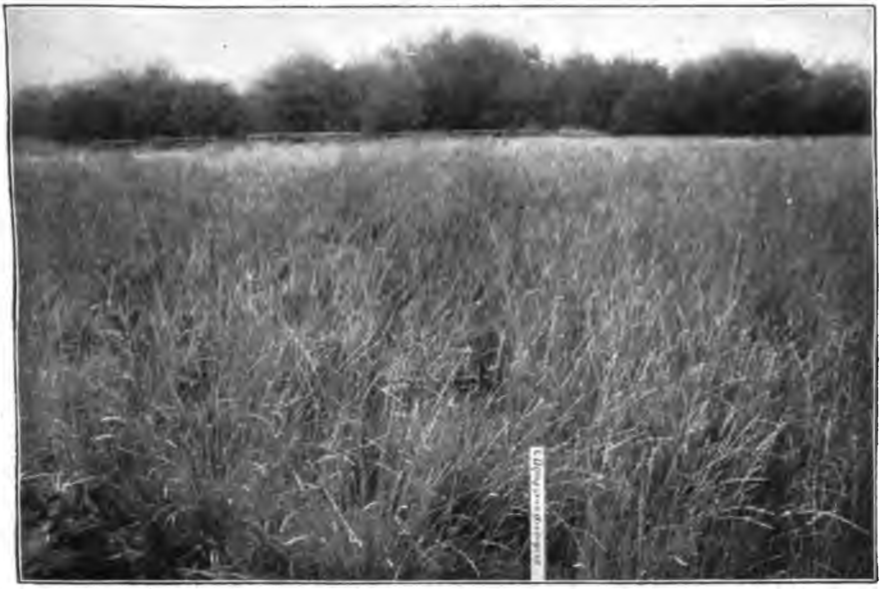


FIG. 1.—BUNCH WHEAT GRASS (AGROPYRON SPICATUM RYDB.). UNITED STATES GRASS STATION AT WALLA WALLA, WASH.

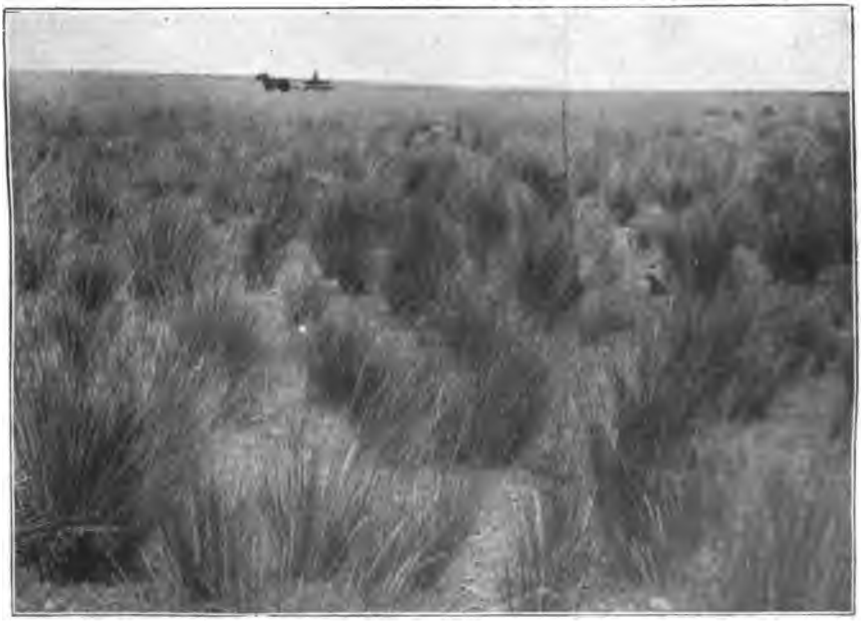


FIG. 2.—BUNCH WHEAT GRASS (NATURAL GROWTH), OREGON.

From a photograph by A. B. Leckenby.

is higher. In the southern part of Colorado it can be profitably grown at an altitude of 7,500 feet, but there are still large areas of suitable lands throughout this region lying at too great an altitude to grow this crop. In this case, as in that of the arid and alkali soils, the solution of the problem is believed to be found in the cultivation and adaptation of the native grasses and forage plants. For the higher altitudes there are several blue grasses (*Poa* spp.) which produce hay of excellent quality. Other excellent species for these localities are species of *Bromus*, especially western brome grass (*Bromus pumpellianus*) and short awned brome grass (*Bromus marginatus*). Various species of blue-joint (*Calamagrostis* spp.) Alpine timothy (*Phleum alpinum*), western foxtail (*Alopecurus occidentalis*) and red fescue (*Festuca rubra*) are all valuable meadow grasses, which produce good forage at altitudes too high for the production of any of the cultivated species. After a description of the forage conditions on the range of western South Dakota and north-eastern Wyoming, consisting of an abstract from the report of Mr. Griffiths for 1897, the cultivated grasses and forage plants which have been tried or give indications of success in this region are fully described, and their particular characteristics and adaptability to particular conditions pointed out. The native grasses and forage plants are also discussed. In referring to the native grasses Mr. Williams says:

> The great economic importance of the native grasses is at once apparent when one recalls the many thousands of sheep, cattle, horses, and mules that are raised in this region, and that depend entirely upon the native grasses and forage plants for subsistence for from eight to twelve months in the year. That the quality of the forage afforded is excellent is shown by the fact that most of the vast numbers of fat cattle and sheep annually shipped to eastern markets from this region received no other food than that furnished by the natural meadows and pastures of the ranges.

The more important native grasses are arranged for purposes of discussion in two groups, meadow grasses and pasture grasses. Of the native meadow or hay grasses the great value of the wheat grasses (*Agropyron* spp.), the rye grasses (*Elymus* spp.), and the blue grasses (*Poa* spp.) is pointed out. The native pasture grasses are treated of under two subheads, "Grasses of the plains" and "Grasses of the foothills and mountains." The grasses of the plains referred to here are those which we have already discussed in dealing with the plains region. The grasses of the foothills and mountains are numerous and consist largely of bunch grasses. Sheep's fescue (*Festuca ovina*), bunch wheat grass (*Agropyron spicatum*), needle grasses (*Stipa* spp.) are abundant and of great value. There is nothing to indicate that these grasses may not be successfully cultivated. In fact, experiments already undertaken with some of them have shown that they adapt themselves readily to cultivation, and there is little doubt that in the near future seeds of these species will be grown and the plants regularly cultivated in this region. The native clovers, vetches, and lupines, as well as rushes, sedges, and other miscellaneous native forage plants, are also given considerable attention. The number of plants in this region, which have a greater or less degree of importance as forage plants, is particularly large, and there is no apparent reason why, by proper preservation and care of the natural forage resources, there should not be produced an abundant supply for all present needs.

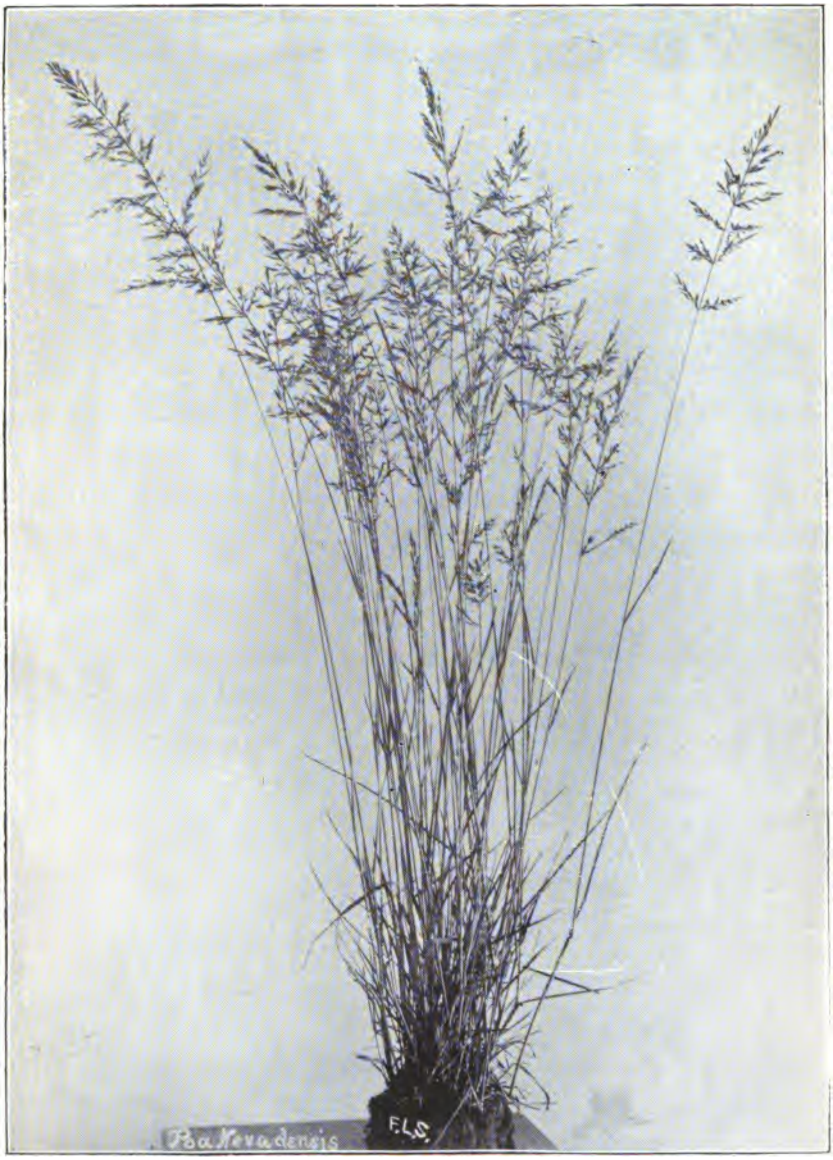
The bulletin closes with a chapter on "Improvement of the ranges," in which the necessity of establishing some system of control, which shall allow each person the exclusive right to graze his stock on a given piece of land, is emphasized. Some of the evils of the present system, or rather lack of system, in the management of the free range are indicated. The importance of the conservation of the rainfall is also mentioned, and the desirability of providing reservoirs or tanks at convenient intervals for supplying stock with water, thus avoiding the necessity of their tramping long distances is pointed out. In speaking of the desirability of experimenting with grasses, for the purpose of selecting and securing varieties adapted to the different soil and climatic conditions of this region, the following advice is given:

> These experiments should not be confined to the tame or introduced sorts, but should be extended to desirable native kinds, such as have been mentioned in the preceding pages. There is no locality without grasses or forage plants worthy of trial under cultivation, and when one can, with but little trouble, obtain enough seed for such a test.

As a means of restricting the ranges in case the grasses have not been too largely exterminated a period of rest is recommended. This gives the grasses opportunity to produce seed and regain their vigor. The great value of disk harrowing and also of alternate grazing is mentioned.

In 1898 the writer, accompanied by Mr. Ernst A. Bessey, made a thorough investigation of the grass and forage condition of northern Colorado. A team and camping outfit were secured at Wolcott, on the Denver and Rio Grande Railroad. From this point we proceeded northward on the road to Steamboat Springs. Stops were made at various points, collections of the various grasses and forage plants were made, and much information regarding range conditions and management secured. In the Bear River Valley, between Yampa and Steamboat Springs, there are considerable areas of meadow lands, which produce, in favorable seasons, large crops of excellent hay. The most prominent grasses are the blue grasses, especially *Poa lævigata*, hair grass (*Deschampsia cæspitosa*), sheep's fescue (*Festuca ovina*), alkali meadow grass (*Puccinellia airoides*) and wire grass (*Juncus balticus*). Considerable alfalfa is grown for winter feed at this altitude.

From Steamboat Springs we continued east, crossing the Park range and investigating the mountain pastures and meadows. Near



Nevada Blue Grass (Poa nevadensis). An important native Grass in the Northwest.

Photographed from plant grown at Washington, D. C., by F. Lamson-Scribner.

UNIV. OF

the summit of the divide and over extensive areas in the more open timber land mountain rye grass (*Elymus glaucus*) occurred in abundance (Pl. XI, fig. 1). This grass is a most excellent one for hay, and as it grows naturally at an altitude of eight to ten thousand feet, is likely to prove of great value for cultivation in such localities. The grass is one deserving of attention, and from past experience with the native rye grasses it seems probable that there will be little difficulty in cultivating it. Seed of it has been secured, and experiments in growing it are being carried on at present in various places. A species of blue grass (*Poa wheeleri*) also grows at this altitude and gives promise of great value for cultivation. Passing from the mountains to North Park work was done in the vicinity of Higho, Lake John, and Hebron. The general elevation here is about 9,000 feet. In the bottom lands along the streams there are many wild hay meadows. Some of them, however, are badly infested with squirrel tail (*Hordeum jubatum*). This grass is becoming a great nuisance throughout this region, and steps should be taken to destroy it. As it matures before the other grasses are ready to cut, its seed become widely distributed. If, however, it were mown before any of the seed had matured, it could be controlled without great difficulty and at the same time be used for hay. Here on the mesa was also found, in small quantities, blue grama. This altitude (9,000 feet) is the highest at which this valuable grass is known to grow. The various wheat grasses form an important part of the forage on the mesa. Wire grass (*Juncus balticus*) and various sedges constitute a considerable portion of the hay, especially in the wetter parts of the meadows. From North Park the work was continued over Muddy Pass and through Middle Park to Grand Lake, then over the Sheephorn Divide and down the valley of the Grand River, returning to Wolcott.

The carrying capacity of much of the range land of this region has not greatly diminished during recent years. From 15 to 25 acres are necessary to carry one head of stock. More judicious pasturing would, however, increase the carrying capacity of much of this land. As stock must be fed during portions of the winter, more attention should be given to the improvement of meadows and the growing of hay. Much of the region is situated at too great an elevation to successfully grow alfalfa. There are, however, several of the native grasses which with proper attention would produce excellent crops of hay. The wheat grasses, western wheat grass (*Agropyron occidentale*) (Pl. XII), slender wheat grass (*Agropyron tenerum*), short-awned brome (*Bromus marginatus*), and the rye grasses, Macoun's rye grass (*Elymus macounii*) and mountain rye grass (*Elymus glaucus*) are adapted to the conditions prevailing here. Seed of these could be collected without great difficulty and sown upon the natural meadow lands to great advantage.

All the land which lies along the water courses has been taken up and fenced and is largely in the possession of a few owners, who from their ability to control the water supply naturally control the use of all the adjacent range lands, as no stock can be kept on the range without a sufficient water supply. Not only this, but in many cases the public range lands themselves have been fenced, thus excluding all other people from placing stock on the land. This very evident injustice is the quite logical result of the lack of any system of controlling the public lands. The grazing lands of Colorado vary greatly in their carrying capacity and condition. From the work which has been done by the Division, not only through personal investigation but by letters of inquiry from various stockmen throughout the State, it appears that while in some localities the ranges are in nearly as good condition as formerly, in others the carrying capacity has been diminished as much as 50 per cent or even more. It is believed that an estimate of an average of 25 per cent decrease in the carrying capacity for the State as a whole would be a fair statement of the case.

No field work was done in this region in 1899, but in 1900 work was carried on at several points. Dr. David Griffiths and Mr. E. F. Lange worked in Montana; Professor Scribner and Mr. E. D. Merrill in Idaho, Wyoming, and the National Park; Mr. Elias Nelson, in southern Wyoming; and Mr. William Shear and the writer in southern Colorado. The work previously done here had been sufficient to afford a very good general knowledge of the forage plants and conditions as well as the most important problems and requirements. Recognizing that, to secure grasses and forage plants capable of succeeding under the unfavorable conditions of soil and climate prevailing over a large portion of the region, very little was to be expected from the introduction of tame grasses, which were only adapted to growth in moister regions; our efforts were directed toward the grasses and forage plants native to the region. As has already been pointed out, there is a considerable number of most excellent grasses native here, and it was deemed desirable to make an effort to introduce these species into cultivation. With this aim in view the chief object of the field work this year was to secure large quantities of seeds of the best native grasses and forage plants. In cases where seed could not be well secured or the plant was most easily propagated from roots these were secured. A considerable collection of specimens was also made incidentally. The results of the work have already been published by the writer in Circular No. 9 of the Office of the Secretary. Much interest was shown in the work by stockmen and ranchmen of the region visited, and expressions of appreciation and encouragement as well as assistance were given. In regard to the results of this season's work we may quote the following from the report referred to:

> As a result of the work in the field this summer seeds of about 130 varieties of grasses and forage plants were secured. These were obtained in quantities varying

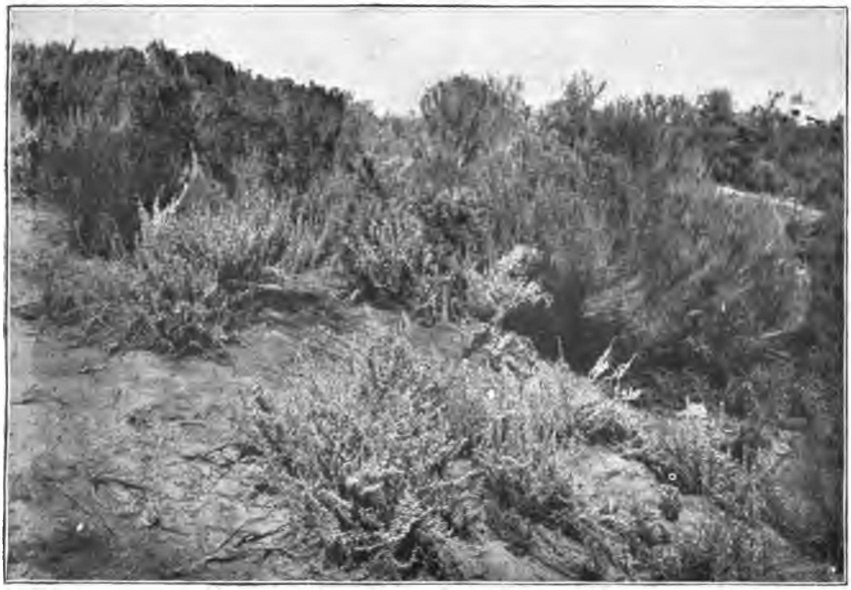


FIG. 1.—WINTER FAT (EUROTIA LANATA). NATIVE GROWTH, PARKER, WASH.

From a photograph by A. B. Leckenby.

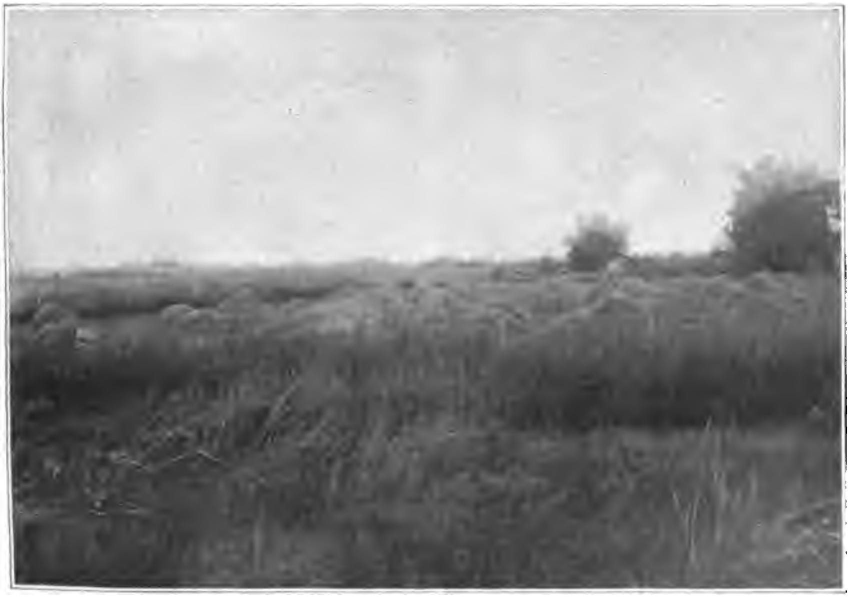


FIG. 2.—A FIELD OF QUACK GRASS HAY (AGROPYRON REPENS), NEAR WALLA WALLA, WASH, SHOWING THE LARGE CROP PRODUCED.

From a photograph by A. B. Leckenby.

from one to five hundred pounds, according to the desirability of the species and the difficulty of securing it. The total amount collected was about 4 tons. Besides seeds a considerable quantity of roots were obtained for transplanting, also several hundred specimens of interesting species for the herbarium or exhibition purposes. Among the most important results of the field work was the information secured by direct observation of the actual conditions and problems to be met in the various regions and by intercourse with the stockmen and ranchmen. This intercourse brings into actual touch the Department and those for whose immediate benefit the work is intended, and so promotes mutual understanding and profit. They come to a better understanding of the methods and aims of the Department, and we come to a better knowledge of their difficulties and needs.

The value of this seed work and the desirability of continuing it was particularly emphasized. The little experience already gained by the cultivation of some of the native forage plants has conclusively shown that there are great possibilities in this direction, and that future investigations will undoubtedly prove that many of these native species can be successfully and profitably cultivated in arid and alkali soils where few or none of our introduced species will succeed. A list of the especially promising species of which seed was obtained in quantity was also given in this circular with notes regarding their distribution and their particular value for special conditions and purposes.

THE NORTHWEST.

CONDITIONS AND PROBLEMS.

Under this head the region included in western Idaho and the portions of Washington and Oregon lying east of the Cascade Mountains will be considered. The conditions and problems here are very similar to those of the Rocky Mountain region, especially of the northern portion of that region. The annual rainfall over the greater part of this territory averages about 15 inches or less. The important forage questions presenting themselves are here, as in the Rocky Mountains, the improvement of the greatly deteriorated range lands and the question of forage for arid and alkali soils. In addition there is the question of the control of the shifting sands at various points along the Columbia River.

WORK DONE.

Field work in this region was commenced in 1898 by Prof. F. Lamson-Scribner, who made a general study of the region. Mr. A. B. Leckenby has done work for the division in this region during the past three years, in addition to having charge of the experimental work which was carried on at North Yakima and Walla Walla, Wash. Professor Scribner, Mr. A. L. Scribner, and the writer did work in this region during the summer of 1899. The range lands in the vicinity of Walla Walla and in the Blue Mountains of Washington and Oregon were investigated; also the ranges and sand dunes in the vicinity of The Dalles. The most important native grasses of the range are bunch wheat grass (*Agropyron spicatum* (Pursh) Rydb.) (Pl. XIV) and several species of blue grass (*Poa* spp.) Winter fat (*Eurotia lanata*) is a native forage plant of considerable value here and also in many localities throughout the arid region. The accompanying illustration shows this plant as it grows at Parker, Wash. (Pl. XVI, fig. 1). Persons who have resided in this region for the past twenty-five or thirty years state that the range lands in the vicinity of the Columbia River in Washington and Oregon were in the early days practically covered with a very abundant growth of the bunch grasses. Through overstocking and drought these bunch grasses have been practically exterminated over large areas and their places occupied more or less by weedy annual plants, especially the soft chess (*Bromus hordeaceus*), which furnishes very little forage. Besides cattle, large numbers of horses have ranged over some portions of the country and have done much to bring about the present unfavorable condition of things. Sheep have also done considerable injury in many places. There has been no effort made by the stockmen to conserve the product of the grazing lands, the lack of any right to control them giving them no inducement to improve or care for them. Early in the course of the investigations in this region the great desirability of testing the more promising native and introduced forage crops which gave promise of success in this region was recognized. Two points were selected at which culture experiments were commenced, one at Walla Walla, in connection with the Oregon Railroad and Navigation Company, and the other at Yakima, on land belonging to the Northern Pacific Railway Company. The work here, which was under the immediate supervision of Mr. Leckenby, served to demonstrate very conclusively the possibilities in the way of cultivation and the great value of some of the native grasses, especially the bunch wheat-grasses, which, as before mentioned, occupied a large portion of the range lands of this region. Other wheat-grasses, as western wheat-grass, (*Agropyron occidentale*) and slender wheat-grass (*Agropyron tenerum*) also showed great adaptability to cultivation and give great promise of usefulness in this region. These grasses will grow with little or no irrigation. The blue grama grass (*Bouteloua oligostachya*), though not a native of this side of the range, proved well adapted to the prevailing conditions. The accompanying illustration shows a small field of quack grass (*Agropyron repens*) grown near Walla Walla. It produced an enormous crop with little irrigation (Pl. XVI, fig. 2). Awnless brome-grass, which was also tried here, gave excellent results.

The sand-binding grasses along the Columbia River were given especial attention. Seeds and roots of many of them were collected in quantity for testing here and elsewhere. Experiments in growing them were carried on at different points along the river and some quite

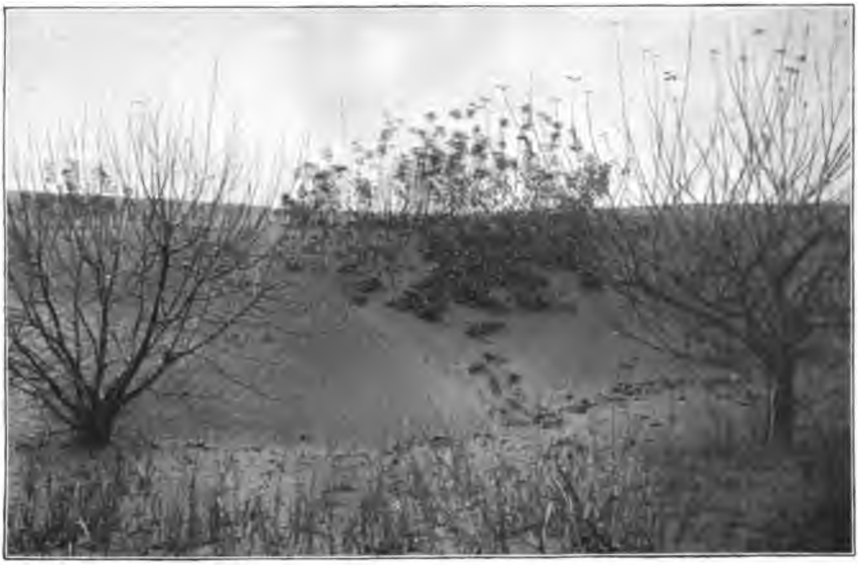


FIG. 1.—SAND DRIFTS ALONG THE COLUMBIA RIVER, OREGON, IN PEACH ORCHARD.

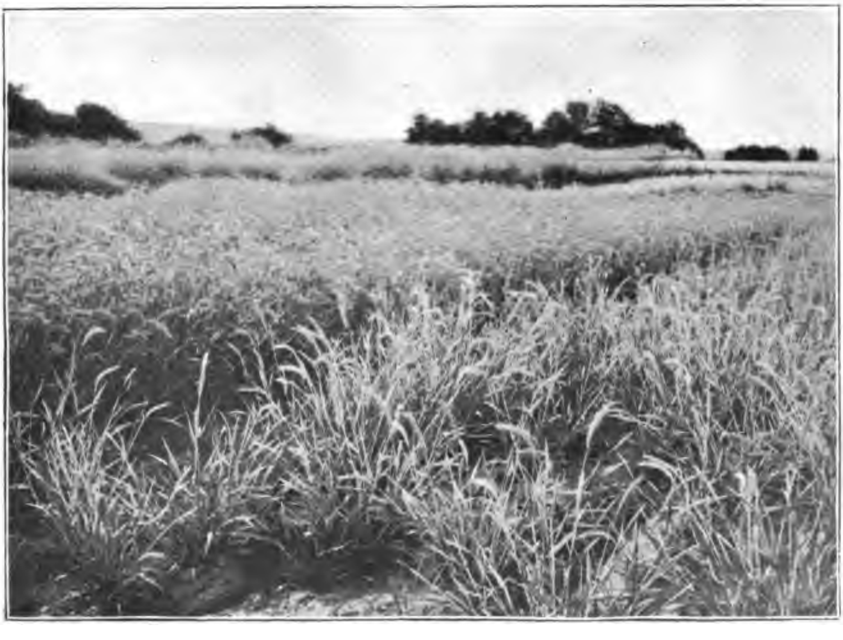


FIG. 2.—VIEW IN GRASS STATION AT WALLA WALLA, WASH., SHOWING CANADIAN RYE GRASS (ELYMUS CANADENSIS).

From a photograph by F. Lamson-Scribner.

encouraging results obtained. The drifting sands along the Columbia, from The Dalles eastward, are a source of great trouble and expense to the railroad company as well as to people occupying the land along the river. The great amount of sand present and the rapidity with which it shifts frequently causes much delay to the railroad traffic, and necessitates considerable expense in keeping the track clear. At some points the sands have encroached upon the cultivated lands, in some instances completely burying orchards and other tracts of valuable land (Pl. XVII, fig. 1). We are told by those familiar with the conditions during the early settlement of the country that there was very little sand along the river, and that it caused little or no damage, but that within recent years the amount of sand brought down by the river has accumulated in greater and greater quantities each year. This large increase in the deposit of sand is no doubt in great part traceable to the deforesting of large areas about the head waters of the Columbia River and its branches, and also to the destruction of much of the plant covering of the hills and mountains by overstocking, thus giving an opportunity for the rainfall to run off rapidly, causing great erosion and carrying large quantities of soil and sand down the streams. Large amounts of sediment are also the product of the mining industries carried on at various points along the Columbia and its tributaries. The lack of a proper covering of the soil which will retain moisture derived from the rainfall and melting snows is also in large part a cause of the excessive floods which have occurred during recent years.

The only publication devoted entirely to the results of work done in this region is circular No. 22, by Professor Scribner, on "Grass and Forage Plant Investigations on the Pacific Coast," in which an outline of the conditions and problems presenting themselves in the region is given, and an account of the experiments carried on at North Yakima and Walla Walla, with especial reference to the native and introduced species which were tried and the degree of success attained. A list was also given of grasses and clovers valuable in the upper Pacific coast region. Besides the large quantities of seed which have been secured, especially of bunch wheat-grass and the wild ryes (*Elymus canadensis* and *Elymus condensatus*), a number of new species of grasses have been collected. *Elymus arenicolus*, *Elymus flavescens*, and *Poa leckenbyi* are new species of important sand-binding grasses which have been found along the Columbia River, and will probably prove of value for introduction into other localities.

In the mountains south of Wallowa Lake, Oregon, we had an opportunity to observe sheep grazing (Pl. XVIII, fig. 1). The effect of the grazing here is apparently not injurious to the timber lands, and where we had opportunity to examine we saw no evidence that it was overgrazed to any appreciable extent. The sheep feed here largely upon the various native plants other than grasses, and are not held long enough in one place to cause any injury. The sheep-grazing industry may be injurious or not, according as it is conducted. In some localities there is evidence that sheep grazing in the forest reservations is conducted in such a manner as to result in great injury to the forests and to the grazing lands, and indirectly to the whole country on account of the inability of the denuded soil to retain the rainfall. We are of the opinion, as already expressed by the Division of Forestry, that sheep grazing under proper restrictions is not necessarily injurious to forest reserves.

THE SOUTHWEST.

CONDITIONS AND PROBLEMS.

It is in this region, which includes western Texas, New Mexico, Arizona, and southeastern California, that the most difficult conditions and problems present themselves. The greater portion of this region presents conditions quite different from those found in any other part of the United States. The most favorable climatic conditions are to be found in central and western Texas. Here the annual precipitation ranges from 25 inches near the center of the State to 15 toward the western border. The greater portion of this part of Texas is excellent grazing land. In fact, there are few areas to be found where the natural conditions are so favorable to stock raising. Considerable change has taken place in the aspect of this country since the departure of the buffalo and Indian, owing to the destruction of bushes, shrubs, and trees, caused by the prairie fires which the Indians are said to have set in order to improve the grazing or which were started accidentally. Very few of these plants survived except in protected situations. As soon as the prairie fires became less frequent the shrubby vegetation spread rapidly, especially the mesquite bean (*Prosopis* sp.). This tree has spread with great rapidity in recent years and now forms a scattered growth over a great portion of central and western Texas as well as throughout the lower altitudes of this whole region (Pl. XIX, fig. 1). The rich and nutritious native grasses and forage plants were exceedingly abundant at the time the stockmen began to bring their flocks and herds to these ranges. The territory was so inaccessible before the coming of the railroads that there was a great abundance of food for all the stock, and the opinion prevailed that the forage resources of the country were inexhaustible. At this time it is said that the grazing capacity of large areas of land was one head of stock to 2 to 5 acres, whereas on these same areas to-day it requires from 10 to 16 acres to carry a single head of stock. The building of the Texas Pacific Railroad in 1883 gave great impetus to the stock-raising industry, which immediately began a rapid development. The grazing being practically free, as no provision had yet been made by the railroads or State for

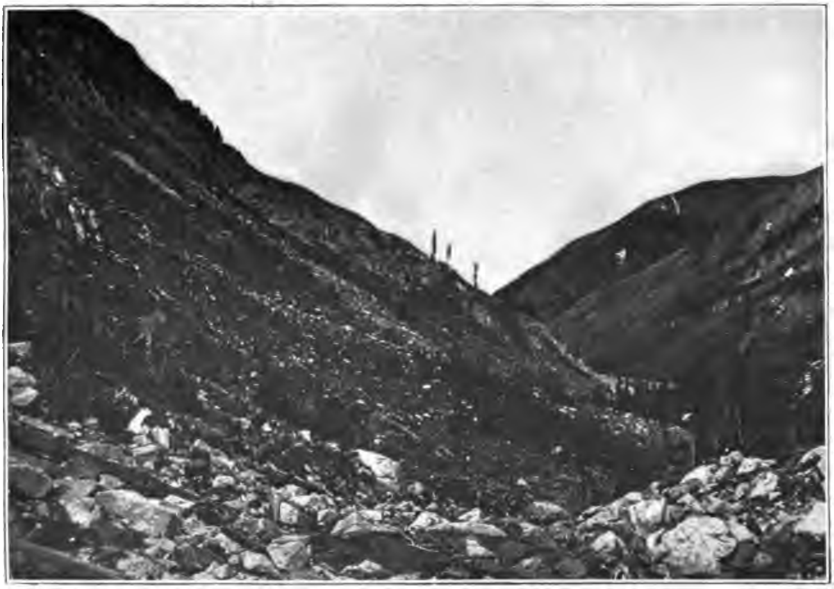


FIG. 1.—SHEEP GRAZING IN THE MOUNTAINS ABOVE WALLOWA LAKE, OREGON.
From a photograph by C. L. Shear.

FIG. 2.—IN THE FIELD. MESSRS. GRIFFITHS AND WILLIAMS IN NORTHERN WYOMING.

controlling their lands, there was a general struggle on the part of stockmen to make the most of the "free grass." The result was a rapid destruction of many of the best grasses by overstocking. The more valuable grasses being gradually destroyed, their places were occupied by more or less worthless annual species, as well as weeds, cacti, and mesquite. On account of the importance of the problems and the interest in them which has been shown by the stockmen, considerable field work has been done in Texas by the Division.

WORK DONE.

Mr. J. G. Smith made a special study of the forage problems of Texas and New Mexico. In 1897 he visited some thirty places in this region and made a careful study of the ranges and the grazing industry. Information was also secured by correspondence with cattle and sheep owners in the State of Texas. These inquiries were directed chiefly to ascertaining the present carrying capacity of the ranges and the amount of increase or decrease in carrying capacity that has taken place during the last twenty-five years. The results of Mr. Smith's work were embodied in Division Bulletin No. 16, "Grazing Problems in the Southwest and how to meet them." This report contains a very thorough account of past and present conditions of the Texas range lands; also the methods which have been and are being followed by stockmen, and the results. The very great decrease in the carrying capacity of the range is pointed out and the reasons clearly indicated. Aside from the destruction of the grasses by overstocking there is a great amount of injury done by animal pests, especially prairie dogs and jack rabbits. These pests were formerly controlled chiefly by their natural enemies, the gray wolves and coyotes, which have been killed by stockmen on account of their destruction of sheep and young cattle. These animals can, however, be controlled without great difficulty if the proper steps are taken. Poisoning has proven to be very effective. The whole section of land upon which the range-improvement experiments of the Division were located at Abilene was entirely rid of prairie dogs in a very short time in this way. The amount of grass destroyed by these animals is enormous. The prairie dogs practically exterminate all the grass in the vicinity of their burrows. The better grasses thus destroyed are replaced by inferior species which have much less feeding value. The rapid increase of the prickly pear (*Opuntia engelmanni*) is discussed and also means of destroying it. Fire is said to be the only remedy which is effective in fighting this plant. The mesquite bean (*Prosopis juliflora*) which we have just referred to as rapidly spreading over the country can scarcely be looked upon as an entirely undesirable intruder. It produces a great abundance of fruit. The pods which are filled with a sweetish, palatable pulp, are greedily eaten by cattle and horses, and are regarded as very nutritious. The fallen leaves are also said to be devoured by stock when forage is scarce. Besides the feed produced by this plant it also furnishes protection for stock during severe winter storms. On the other hand these mesquite bean groves furnish protection for various noxious weeds and shrubs. They also interfere with the development of the better grasses, which will not thrive in the shade.

In the more arid portions of New Mexico and Arizona there can be no question of the great value and importance of the mesquite bean (*Prosopis* sp.). Its relation to the forage problem here is indirect, but its influence on the general welfare of the country can scarcely be overestimated. In the valleys of the larger streams, as the Santa Cruz in the vicinity of Tucson, the prevailing species grows abundantly along the river and also extends in a small form far back from the river. The trees in the immediate vicinity of the river grow to large size. The timber has, however, been very largely destroyed by cutting it for fuel, and if the present practice of cutting all the available plants for this purpose is continued it will not be long before this valuable heritage will be destroyed. Efforts should be made to prevent further devastation of this valuable plant. The accompanying illustration shows the method followed in cutting such trees (Pl. XIX, fig. 2). The stumps are cut very high, and as the plant possesses great vegetative power and vitality, large numbers of strong shoots arise from the stumps and, growing with great rapidity, soon produce a considerable amount of fuel, so that successive cuttings are made in this way at intervals of a few years.

Mr. Smith points out the great need of practical and scientific measures being used in order to restore and protect the natural grazing lands, and discusses the various methods which give promise of success. The great advantage of alternation in pasturing is particularly mentioned. It has been shown that resting a pasture for a period, especially at the time of seed production, results in great improvement by giving the grass an opportunity to recuperate and to produce a crop of seed. In this connection we may quote the following:

> A rest of two or three months during the growing season in early spring would enable the early grasses to ripen and shed their seeds, thus perpetuating the species. After the seed had fallen the cattle could be turned on the grass for two or three months and again transferred to a fresh pasture. In the same way autumn and winter pastures can be secured.

The other means of range improvements which have been so successfully tried at several places are described. The method and advantage of making stack silage when there is a scarcity of feed are given. The desirability of providing water, either in the form of tanks or wells, so that the stock will not be required to travel long distances, and thus tend to the destruction of the grasses on the areas in the

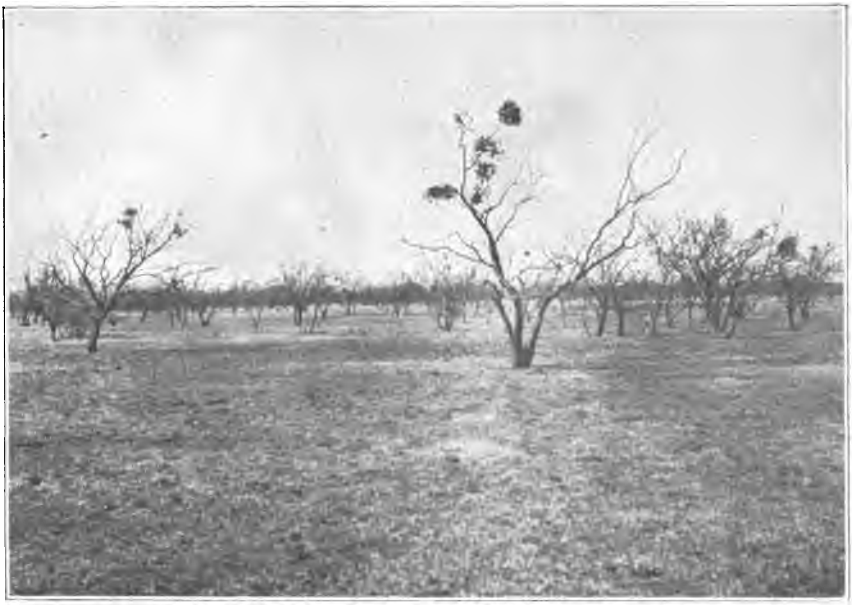


FIG. 1.—RANGE NEAR ABILENE, TEX., WHERE IMPROVEMENT EXPERIMENTS WERE CONDUCTED, SHOWING CHARACTERISTIC GROWTH OF MESQUITE BEAN (PROSOPIS JULIFLORA).

From a photograph by C. L. Shear.

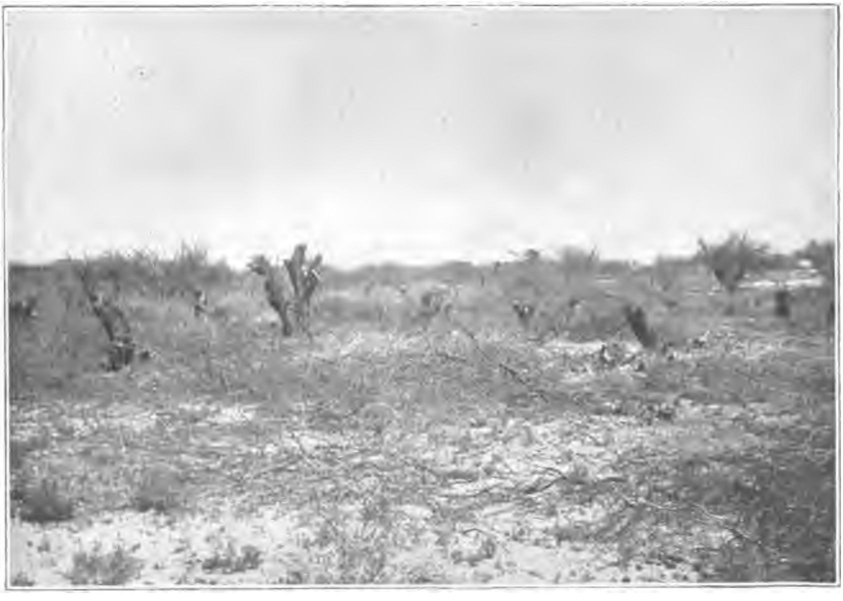


FIG. 2.—VIEW IN THE SANTA CRUZ VALLEY NEAR TUCSON, ARIZ., SHOWING THE MANNER IN WHICH THE MESQUITE BEAN (PROSOPIS SP.) IS BEING CUT.

From a photograph by D. Griffiths.

immediate vicinity of watering places, is urged. Following the discussion of the above subjects, the grazing regions in Texas and New Mexico are taken up and described. The characteristics of the prominent grasses and forage plants are given, with special reference to the more important species and their value. Finally, the relation of land laws to range improvement is considered, and the necessity for some method of control and management of the public grazing lands of the West is pointed out. An estimate is made that an increase of at least $25,000,000 would result from the improvement of the ranges even to the extent of 25 per cent, which improvement has been demonstrated to be easily possible.

Mr. C. C. Georgeson, Mr. T. A. Williams, Mr. H. L. Bentley, and the writer have also done field work in Texas. Mr. Georgeson visited Texas in 1898 for the special purpose of selecting lands and arranging for experiments in range improvement. He visited Abilene and Channing, planning and inaugurating the work at both places. Mr. Williams did some field work in Texas in the spring of 1900. He visited the experiment station at College Station and also the range-improvement experiments at Abilene and Channing. Mr. Bentley, in connection with his duties as special agent in charge of the grass station at Abilene, has done considerable field work and made collections of seeds, roots, and specimens. His chief duty, however, has been the carrying on of the experiments in range improvement which were undertaken three years ago on a section of worn-out pasture land situated near Abilene. As a result of Mr. Bentley's work and experience in Texas he prepared Farmers' Bulletin No. 72, on "Cattle Ranges of the Southwest," in which the various problems are discussed in a condensed and non-technical manner. The various means to be used in the renovation and improvement of the ranges are discussed and clearly indicated. There is also a list of the promising grasses and forage plants native of the Southwest, with illustrations and descriptions of many of them. This bulletin has been in great demand and has done much to arouse interest in the subject. Mr. Bentley has also written a report upon the grasses and forage plants of central Texas, which was published as Bulletin No. 10 of this division. This bulletin covers much the same ground as the one just referred to, going into more detail, however, on some points and giving a much more complete list of the forage plants. It contains many valuable notes regarding the native species and indicates which are most likely to prove valuable under cultivation. It scarcely comes within the province of this bulletin to discuss the experimental work carried on at Abilene, as Mr. Bentley is now preparing a full report upon this work for publication. It may, however, be well to state that it has been demonstrated that disk harrowing of worn-out pasture land each spring for three successive seasons has doubled, in the estimation of three competent disinterested stockmen, the carrying capacity of the range. The carrying capacity of the range at the beginning of the experiment was estimated by the judges to be one head of stock to 16 acres. Stock was kept on the land on this basis for the next season, when it was estimated that the carrying capacity was 1 to 10. Stocking was continued for the next year at that rate, and in the same way until the close of the third year, with the results given above. Partial results of this work have already been published. In Division Circular No. 8 Mr. J. G. Smith gave an outline of the work as planned and inaugurated. In circular No. 23 Mr. Bentley described the progress of the experiments during the first two years.

In New Mexico and Arizona the most unfavorable conditions are to be met with. A great portion of these Territories lies within what is known as the Great Basin, and over considerable areas real desert conditions prevail. The annual precipitation, while reaching in a single limited area as high as 20 inches, is, over most of these Territories, between 10 and 15 inches, while in southwestern Arizona and southeastern California there is an extensive region having an average rainfall of 5 inches or even less (see map 8). It will be readily seen that where the amount of rainfall is so small as that indicated the question of maintaining grasses and forage plants is a most difficult one. Notwithstanding these untoward conditions a considerable number of good grasses and forage plants have succeeded in surviving the struggle for existence here and have become adapted to the environment. We learn from the accounts of early explorers that large areas of excellent grass lands were formerly found in this country, especially in the valleys of the rivers. Our knowledge, however, of the ranges of these two Territories as a whole is, even at present, quite limited. Many portions of the country have never been visited by anyone who has given any special attention to the grasses and forage plants. The first work carried on by the Division in this section was done by Mr. C. R. Orcutt, who spent about three months here—from February to May—in 1896, leaving San Diego, Cal., going eastward to the San Felipe Valley, thence to the Colorado Desert, and across the Mojave Desert to the Colorado River. From here he went to Kingman, Congress, Phoenix, Tempe, Mesa, Maricopa, Tucson, Benson, and Bowie, thence across southern New Mexico by way of Deming to El Paso. From El Paso he went northward up the Rio Grande to Albuquerque, and from there westward by way of the Atlantic and Pacific Railroad across New Mexico and Arizona. The report of this work has not been published. The season during which this work was done was most unfavorable for studying the forage conditions of this country. The reason for this will appear more evident after an examination of the average rainfall for each month in the year. The distribution of the rainfall here is quite different from that of any other

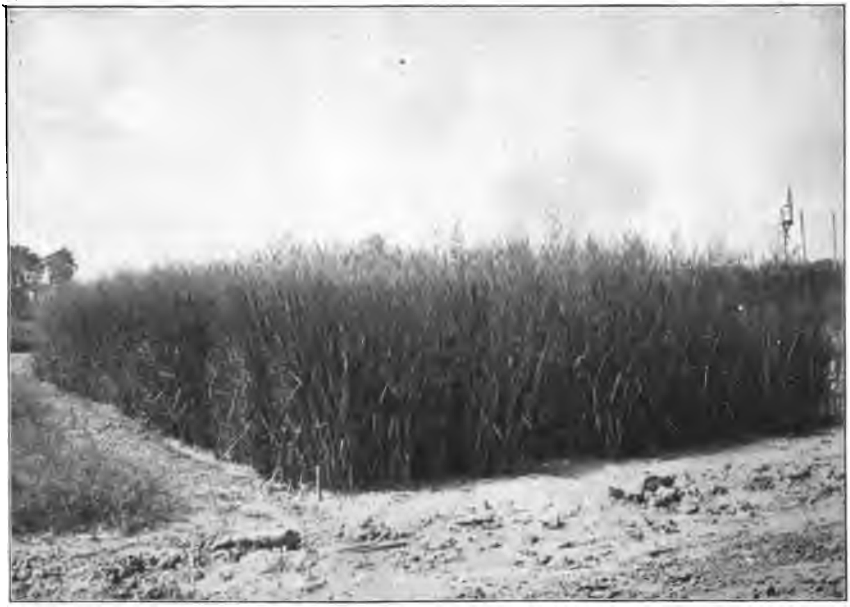


FIG. 1.—BULBOUS PANIC-GRASS, OR TURNIP GRASS, (PANICUM BULBOSUM). GROWN ON POTOMAC FLATS, WASHINGTON, D. C., FROM NEW MEXICAN SEED.

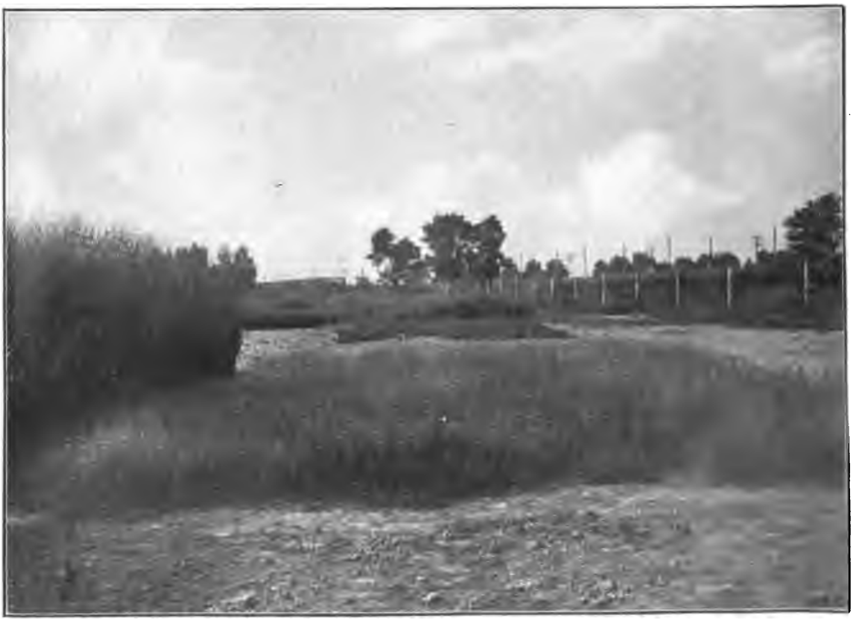


FIG. 2.—CURLY MESQUITE (HILARIA CENCHROIDES). GROWN ON POTOMAC FLATS, WASHINGTON, D. C.

portion of the United States, from 15 to 25 per cent of the annual precipitation occurring during July and August, the smallest amounts occurring in May and June, the water supply rapidly decreasing during the late winter and spring months. As a result of this the grasses and forage plants are at their best during the autumn.

Mr. Orcutt, however, secured a considerable amount of information from the stockmen and ranchmen regarding the grasses and range conditions. Mr. J. G. Smith, in connection with his work in Texas, which has already been referred to, also spent some time in New Mexico, particularly in the Pecos Valley and about Silver City in the southwestern part of the Territory. Mr. Williams also spent a short time in New Mexico in the spring of 1900 and visited Tucson, Ariz. The special purpose of this trip being to arrange for cooperative work with the experiment stations, very little opportunity was afforded for the investigation of the ranges. The results of Mr. Williams's work are published in Circular No. 8, Office of the Secretary. The particular problems in each State and Territory visited were discussed in this paper. The great need of undertaking some work looking to the improvement of the ranges and the introduction and cultivation of hardy forage plants in these two Territories was pointed out, and arrangements were made with the Arizona and New Mexico experiment stations to carry on investigations along these lines. These experiments have already been undertaken, but have not progressed far enough at present to produce any decided results.

During the autumn of 1900 Dr. David Griffiths, special field agent of the Division, was detailed to Arizona to look after the cooperative work just referred to, and also to make a collection of seeds of the native grasses and forage plants. Dr. Griffiths spent several weeks at this work and succeeded in obtaining large quantities of seed of some of the best of the native grasses and other forage plants. He also procured a considerable number of specimens, a list of which has recently been published in Circular No. 32 of this Division. The seed secured by him were used chiefly in carrying on experiments in Arizona and New Mexico, with a view to determining the possibilities and behavior of these plants under cultivation. Mr. James K. Metcalfe, who lives in the vicinity of Silver City, N. Mex., although not officially connected with the Division, is very much interested in the propagation of the native forage plants, and has done much valuable work in this direction. Through his aid the Division has been able to secure quantities of seed of a number of very valuable native forage plants. Of these we may mention particularly the bulbous panic grass (*Panicum bulbosum*). The accompanying illustration (Pl. XX, fig. 1.) gives an idea of the behavior of this plant under cultivation. The illustration shows a plat of this grass grown on the Department grounds on the Potomac Flats. The chief value of this plant lies in its great ability to endure drought. It also tolerates a considerable amount of alkali in the soil. It has been grown successfully for several years by Mr. Metcalfe at his ranch, and the Division is making special effort to introduce it into cultivation at various points in the southwest. It produces large crops of excellent hay as well as pasturage. Mr. Metcalfe was also the first to call attention to a native bean (*Phaseolus retusus*), which has been called in his honor "Metcalfe's bean." This plant produces excellent forage and is well adapted to withstand the arid conditions of the southwest. Quantities of seed of mountain brome (*Bromus polyanthus paniculatus*), Fendler's blue grass (*Poa fendleriana*), sprangle top (*Leptochloa dubia*), and a variety of Canadian rye-grass (*Elymus canadensis*) are some of the other important species which have been secured through Mr. Metcalfe's assistance.

Besides the work referred to above, the writer spent several weeks in this region during March and April of this year. The condition of the range in the vicinity of Abilene, Tex.; Mesilla Park, N. Mex., and Tucson, Ariz., was investigated. As already remarked, at this season of the year the range is in the most unfavorable condition for study, as most of the grasses have been eaten down or, in the case of annual species, passed away. An examination of the range at this time will, however, reveal the basal portion, at least, of the perennial grasses, if any are present, so that one can secure some idea of the possibilities of the ranges at a more favorable season of the year. The greater part of the range lands that were examined, especially those in the valleys and on the mesa, were almost devoid of grass vegetation. The ranges have been so heavily overstocked that the greater portion of the better perennial grasses have been entirely destroyed. This is particularly true of those portions of the range situated within easy distance of a more or less permanent water supply. Owing to the very scant and uncertain supply of water over large areas it has been impossible to graze stock for a sufficient period to destroy the grasses. The constant herding of stock in the vicinity of watering places has resulted in many cases in almost total destruction and abandonment of those ranges. The accompanying illustration will give an idea of the amount of forage present at this season of the year on such a range (Pl. XXI, fig. 1). Aside from a few species of annual weeds, which start up in the spring, there is practically no vegetation except the ever-present creosote bush and cacti. Most of these annual weeds are very small and of but little value. There is but one or two that is of sufficient importance to receive any serious consideration. These are species of plantain (*Plantago fastigiata* Morris) (Pl. XXII, fig. 1*a*), and another closely related species. These are small weedy annuals which would be regarded as worthless in almost any other region, but are of value here as being practically the only plants furnishing pasturage over vast areas during this season of the year. The difficulties of range improve-

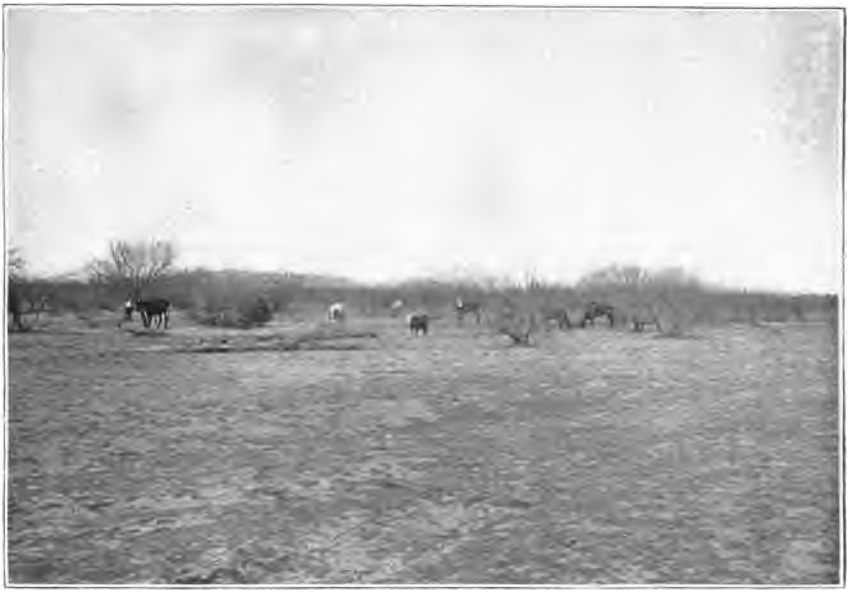


FIG. 1.—THE RANGE, 25 MILES SOUTHEAST OF TUCSON, ARIZ., SHOWING ITS CONDITION EARLY IN APRIL, 1901. ONLY A FEW SMALL, SCATTERED ANNUAL WEEDS PRESENT.

From a photograph by D. Griffiths.

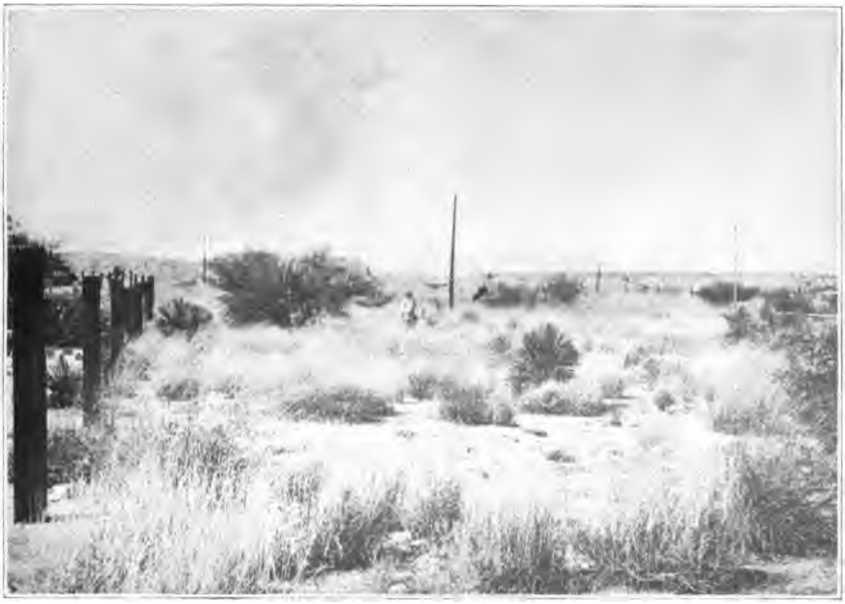


FIG. 2.—ALONG THE RIGHT OF WAY OF THE RAILROAD NEAR BENSON, ARIZ., SHOWING THE CONDITION OF THE GRASS UNDER PROTECTION.

From a photograph by D. Griffiths.

ment under such conditions will be readily recognized, as the range can not be recovered except by seeding. The methods of resting and disking have little hope of success here, as the grasses having been practically destroyed, none are left to reseed the land.

Of course, the condition of affairs described above represents the extreme. We are told, however, that there are extensive areas throughout these territories where the ranges are in the same condition. The effect upon the country of this denuding of the ranges is not restricted to the stock-growing industries, but affects the whole future of the country. One of the most serious immediate results is the erosion which follows the removal of vegetation from the surface. This erosion is so rapid and so great as to be almost beyond belief to one who has not actually observed it. The scanty rainfall, which usually comes in torrents, runs rapidly away over the bare surface of the soil, flowing through and rapidly eroding every shallow depression, so that it becomes only a matter of a few years when a cow-path or a wagon track forms an arroya several feet wide and deep. We had pointed out to us by reliable observers examples of erosion of this sort which have been produced within the past six or eight years. The accompanying illustrations show the results of nine years of this erosion in the vicinity of Tucson (Pl. XXIII). Besides the injuries caused by erosion are those resulting from floods and the deposition of the great amount of soil which is carried down by the streams. It will be seen from this that aside from the desirability of covering these barren lands with vegetation for forage purposes, there is still a greater necessity of covering them in order to conserve the rainfall and prevent this destructive erosion. However discouraging the case may appear, we do not regard it as hopeless.

The first and most important step looking toward the improvement and restoration of the public grazing lands is the control of these lands in such a manner as to make it to the advantage of the stockmen to improve the range rather than to devastate and destroy it, as is the tendency at the present time. This is the question of most fundamental importance, for no matter what temporary improvement may be brought about it can not be made lasting without there is some means of protecting the range from overstocking. The resources of this region, so far as native grasses and forage plants are concerned, are great, and if properly conserved and cared for will be found to meet, for the greater part, the needs of the country.

Several species of mesquite (*Hilaria* spp.) are common and furnish a considerable percentage of the pasturage on the range, particularly on the mesas. Curly mesquite (*Hilaria cenchroides*) (Pl. XX, fig. 2.) is one of the most excellent grazing grasses in the southwest. It is a so-called "short grass," forming a dense turf, spreading by means of runners and producing an abundance of very nutritious forage. It is in habit much like buffalo grass and blue grama grass, and replaces those species largely in western Texas and New Mexico. The black mesquite or black grama (*Hilaria mutica*), also called "gietta" in New Mexico and Arizona, is a very important species and one of great value in this region. *Hilaria rigida*, stiff mesquite, is also called "gietta." It is a rather coarse, harsh grass, growing in bunches, usually about 2 feet high; being able to survive the most arid conditions it is of especial value, as it is almost the only forage occurring in some places. It is not a grass that would appeal to the fastidious tastes of stock accustomed to the tender grasses of moister regions, but stock accustomed to this region eat it with avidity. It is a very nutritious grass and makes a very large growth immediately after a slight rainfall. Mr. Orcutt mentions that it is said to cause death to horses and cattle in case of stock just taken from alfalfa, but injury to range cattle from this cause has not been reported. Perhaps next in importance to the mesquite grasses are the grama grasses (*Bouteloua* spp.). *Bouteloua eriopoda*, woolly-foot grama, is one of the most valuable range grasses in this region, especially in southern Arizona, New Mexico, and Texas. It is a perennial, very hardy and nutritious, and is worthy of cultivation. Several other grama grasses are of more or less importance here. The blue grama, which is such an important grass on the ranges farther east, is not so abundant here. It occurs, however, in the northern part of this region, and is of great value wherever found, though not adapted to endure the extreme conditions of heat and drought to be met with in many parts of this country. Six weeks' grama (*Bouteloua aristidoides*) is an annual species which has assumed considerable importance since the destruction of the better perennial grasses (Pl. XXIV). It springs up immediately after the summer rains, growing very rapidly, as its name indicates, and producing considerable feed during the autumn. Low grama (*Bouteloua polystachya*) is another one of the so-called six weeks' grasses furnishing considerable forage in many places immediately after the rainy season of this region. Quite a number of other species of grama grasses occur, but are less abundant and important than the ones already mentioned. The triple-awn grasses (*Aristida* spp.) are also of considerable importance. They tend to spread and replace the better turf-forming grasses, which have been destroyed. When young they are quite readily eaten by stock, but when they have reached maturity they are avoided by stock unless driven to them by want of better feed. Several species of *Muhlenbergia* also furnish some feed in the foothills and canyons. A number of species of *Sporobolus* ("saccaton") are of considerable importance in this region, especially *Sporobolus cryptandrus*, *Sporobolus airoides*, alkali fine top, and *Sporobolus wrightii* (Wright's saccaton). The latter species is an especially robust and luxuriant bunch grass, formerly found in large quantities on the river bottoms of southern Arizona.

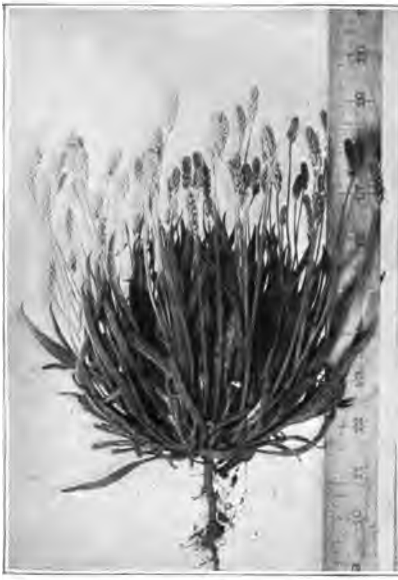


Fig. 1*a*.—Plantain (Plantago fastigiata Morris). A valuable annual forage plant in southern Arizona.

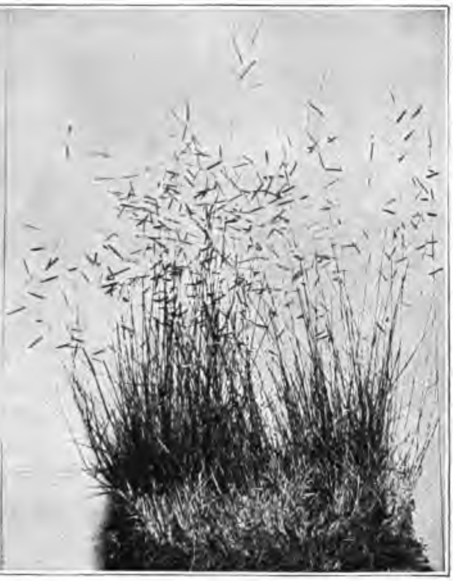


Fig. 1*b*.—Blue Grama (Bouteloua oligostachya) as it grows in Arizona.

From photographs by D. Griffiths.

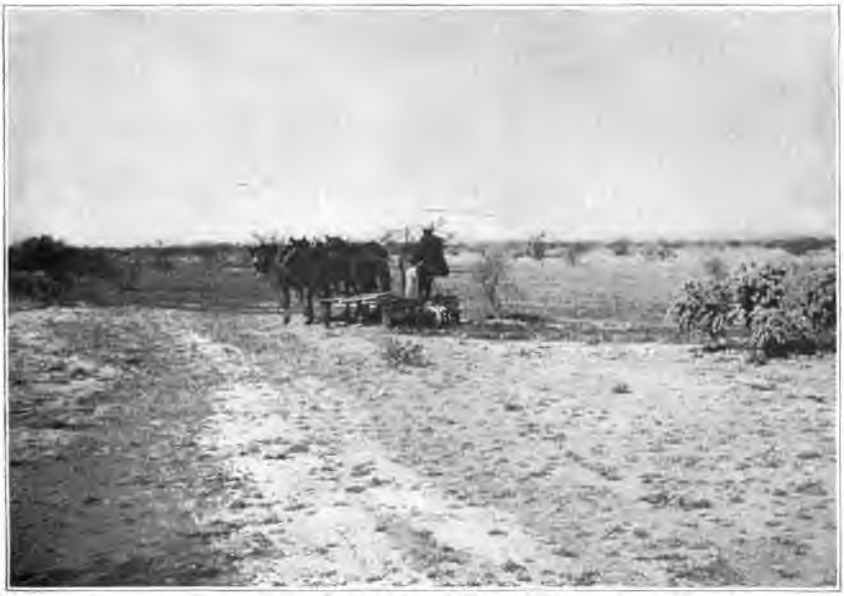


Fig. 2.—Range improvement experiment, Tucson, Ariz., showing the condition of the pasture and the method of disk harrowing.

From a photograph by D. Griffiths.

It is very coarse and rank, and would probably not be touched by stock where more tender and succulent grasses were to be found, but here, where there may be no alternative between it and the thorny cacti to sustain life, it is devoured. The accompanying illustration (Pl. XXV, fig. 2) shows some of this grass after it has been grazed. The wool grass (*Pappophorum vaginatum*), sprangle top (*Leptochloa dubia*), blunt panic grass (*Panicum obtusum*), *Chloris elegans* and feather beard grass (*Andropogon torreyanus*) are also species of considerable importance. Fendler's blue grass (*Poa fendleriana*), sometimes locally called mutton grass, is a valuable species, occurring in the foothills and mountains and furnishing palatable and nutritious feed. During certain seasons of the year, and in some locations, plants other than grasses form the most important portion of the grazing. Some of these plants are of considerable value and worthy of serious investigation with a view of introducing them into cultivation. Others are eaten only as a last resort when stock are threatened with starvation, and could scarcely be classified as forage plants. To this last category we may refer the various species of spiny cacti, with which the heads of animals are occasionally found covered during periods of extreme drought and scarcity of food. Species of yucca, especially *Yucca elata*, are sometimes browsed in cases of scarcity of better food. The shad scale (*Atriplex canescens*) and winter fat (*Eurotia lanata*) are valuable forage plants which grow naturally here, and may perhaps be cultivated to advantage. The accompanying illustration shows the shad scale grazed and ungrazed (Pl. XXVI).

The above are some of the most important species of native grasses and forage plants, and where the rainfall of the region must be depended upon for the supply of moisture, experience indicates that it is to these native plants that we should look for species to grow for hay and pasture. The only reasonable hope for success with introtroduced species is in the case of those which are brought from regions where much the same climatic conditions prevail. Plants introduced from Central Australia and other high arid or desert regions may, perhaps, be grown with success, as for instance, the Australian saltbush. Species of spineless cacti might profitably be experimented with here and also investigations carried on in the selection and breeding of spineless forms of the native species. In regard to the restoration of the range, where the better grasses have been practically destroyed, it will be necessary to break the soil by harrowing, preferably with a disk harrow, and sowing seed of the native species. This sowing should be done about the time of the commencement of the summer rainy season in order that the young plants may have the full benefit of the moisture supply. Stock should, of course, be kept from these seeded areas until the grasses have had an opportunity to become firmly established. Wherever possible supplies of water should be provided at points which would not necessitate long journeys on the part of stock to secure drink. By proper treatment ranges which still have a sufficient supply of grass left to reseed them may be reclaimed by disking and allowing a period of rest or by alternating periods of pasture and rest, allowing the grasses to produce seed. Where there are facilities for irrigation there is little trouble in the selection of good forage plants. Alfalfa can be successfully grown in most portions of the region. In the Santa Cruz Valley barley is grown extensively for green feed and hay. Alfalfa is also an important crop here. The different varieties of nonsaccharine sorghums and also the millets may be profitably produced under irrigation.

THE PACIFIC COAST.

CONDITIONS AND PROBLEMS.

The Pacific Coast region, as discussed here, will be confined to the country lying west of the Cascade and Coast Range mountains. There is considerable variation in the climatic conditions at various points in this region. For instance, near the southern part of California the annual rainfall averages 10 inches, while on the coast of northwestern Washington there is a small area having an annual rainfall of 100 inches. From San Francisco northward, however, the differences are not so great, the annual precipitation varying from 30 to 100 inches. The rainy season in this region is during the winter, the greatest rainfall occurring in December and January, with a rapid decrease of precipitation as the spring and summer advances, so that during June, July, and August there is little and sometimes no rain. It will be noticed that over the greater portion of this region there is a sufficient moisture supply to meet the needs of most forage plants, so that it is only in very limited areas that arid conditions are to be met with. The real range lands here are quite restricted as compared with those in the Great Basin and Rocky Mountain region, as there are extensive forest areas all along the coast. There are, however, frequent openings in the woodlands which are termed "prairies," and in many places open or brush-covered range lands in the foothills and mountains.

The dairying industry is perhaps the most important one in this region. Stock growing, however, assumes considerable importance at certain points in California and Oregon.

The control of the shifting sands, which are menacing and in many places destroying the agricultural lands at certain points along the coast, is a matter of great importance.

WORK DONE.

Considerable work remains to be done here, as there has been opportunity thus far to do but a limited amount of investigation.

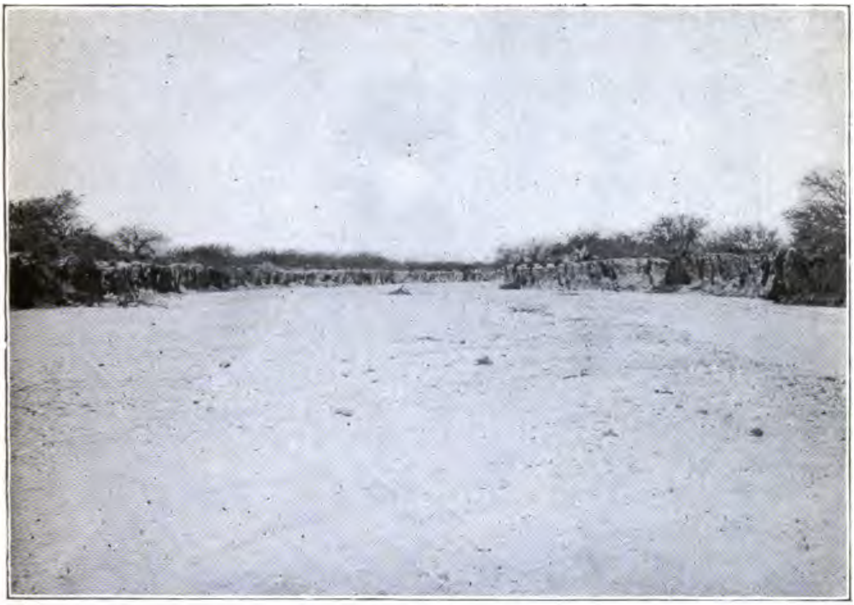


FIG. 1.—A "WASH" NEAR TUCSON, ARIZ. THE RESULT OF BUT NINE YEARS EROSION.
From a photograph by D. Griffiths.

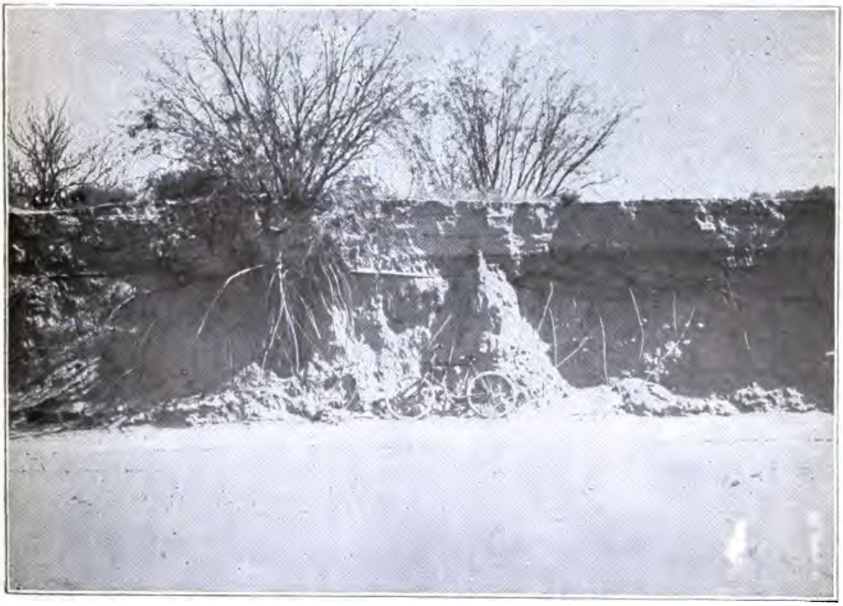
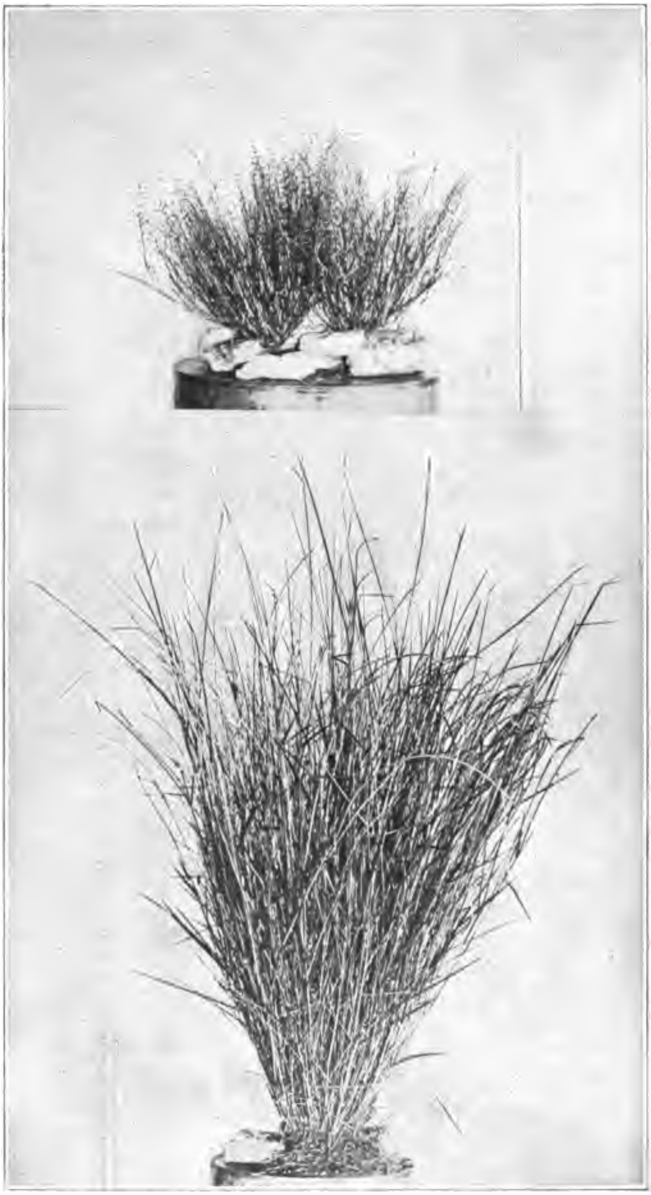


FIG. 2.—THE SIDE OF THE SAME "WASH," SHOWING THE DEPTH.
From a photograph by D. Griffiths.

Mr. Leckenby has spent considerable time in the study of the sand dunes on the Oregon coast at the mouth of the Columbia River, and south as far as Seaside. Professor Scribner has also investigated the sand dunes in this same vicinity and at various points in California, especially at Los Angeles, San Francisco, and points northward. The most thorough and extended investigations in this region have been made in northwestern California, by Mr. J. Burt Davy, special agent of the Division. His investigations covered the region included in the counties of Lake, Mendocino, Humboldt, Trinity, Del Norte, and the western part of Siskiyou. Mr. Davy made a very careful and thorough study of the conditions and problems in this region, and has prepared a comprehensive report of the whole subject, which is nearly ready for the press. The writer has also done some field work in this region. Work was done in connection with Mr. Leckenby and Professor Scribner at Seaside and Gearhart where the sand dunes and the native sand binders were studied and quantities of seed collected. Work was also done in the vicinity of Portland and McMinnville, also at San Francisco and vicinity. Very little investigation of the ranges of this region has been made, except by Mr. Davy. He reports the ranges of northwestern California greatly deteriorated on account of overstocking and injudicious methods of grazing. This has been carried on to such an extent that most of the forage at present found on the range consists of introduced plants which have taken possession of the land since the destruction of the native grasses and forage plants. Fortunately these introduced species have some forage value. They are chiefly soft chess (*Bromus hordeaceus*), alfilaria (*Erodium* spp.), and wild oats (*Avena*, probably *A. barbata*). The wild oats, however, is said to be much less common than formerly. Of the native grasses species of wild rye (*Elymus* spp.), brome grasses (*Bromus* spp.), hair grasses (*Deschampsia* spp.) wild-oat grass (*Danthonia* sp.), prairie June grass (*Kœleria* sp.), and fescues (*Festuca* spp.) are now to be found only in protected situations, though they were probably, as Mr. Davy points out, much more abundant formerly. Several native species of clover (*Trifolium* spp.) are also valuable for forage. The restoration of the ranges here, as elsewhere, must depend upon proper and continuous treatment. Where the native grasses have been practically exterminated seeding with some of these or with introduced species adapted to the conditions will probably be necessary. In other instances, allowing the range a period of rest or alternate periods of grazing and rest, thus giving the plants an opportunity to produce seed, will produce beneficial results. Where dairying is carried on cultivated forage plants are depended on largely for grazing and hay. Oats and wheat are most extensively grown for hay. In western Oregon considerable chess (*Bromus secalinus*) is grown for hay, also the ray grasses (*Lolium* spp.). while velvet grass (*Holcus lanatus*) is abundant and has taken possession of many meadows. Some timothy, redtop, and a little alfalfa have also been grown. Permanent hay meadows would no doubt be an advantage, however, and there is reason to believe that there would be little difficulty in securing cultivated grasses which would be successful here. Meadow oat grass (*Arrhenatherum elatius*), orchard grass (*Dactylis glomerata*), meadow fescue (*Festuca pratensis*), and red clover (*Trifolium pratense*) can be successfully grown according to Mr. Davy. With so large a number of available grasses and forage plants to choose from there should be little difficulty in providing pasture the year round, and this seems to be one of the things most desirable in order to secure the greatest success for the dairying business. Soiling crops could no doubt also be grown to advantage.

Considerable work has been done in the study of the sand dunes and the study and collection of the native sand binders. Large quantities of seeds and roots of the native sand binders have been collected for distribution and transplanting. Seaside blue grass (Pl. XXVII, fig. 1) (*Poa macrantha*), which is abundant on the Oregon coast and which is very efficient in holding drifting sands, has been distributed to various places in the interior and on the Atlantic coast, where it is hoped that it may be successfully introduced. Sand rye-grass (*Elymus arenarius*) is also an excellent native sand binder. Big-head sedge (*Carex macrocephala*) is abundant on the Oregon coast at Seaside (Pl. XXVIII). This is a plant which spreads very rapidly by running rootstocks and performs very efficient service in holding the drifting sands. Roots and seeds of this plant have also been collected for use in experiments in other localities, where it is hoped that it may be successfully introduced. *Abronia latifolia* and lupines are also of considerable importance as sand binders and worthy of trial elsewhere.

No publication has yet been issued by the Division dealing specially with the work done in this region. Circular No. 22 on "Grass and Forage Plant Investigations on the Pacific coast," with the exception of a slight reference to sand-binding grasses, treated entirely of the work done east of the Cascade Mountains, which has already been referred to under the discussion of the Northwest. The results of Mr. Davy's work are nearly ready for publication, and as they will treat of the different problems very thoroughly and in detail it will not be necessary for us to give more than the outline of the work which has already been given. The portions of this region lying between Seaside and the southern boundary of Oregon and extending from the coast to the mountains is in need of exploration and investigation, and will no doubt repay careful study. The dairying interests are particularly important here, and the value, abundance, and distribution of the native grasses and forage plants is little known.



THE UPPER PLANT, SIX WEEKS GRAMA (BOUTELOUA ARISTIDOIDES); THE LOWER, A DROP SEED (SPOROBOLUS CRYPTANDRUS STRICTUS); BOTH NATIVE ARIZONA GRASSES OF CONSIDERABLE IMPORTANCE.

From a photograph by D. Griffiths.

GENERAL SURVEY AND SUMMARY.

The field work already described includes investigations which have been carried on in 32 States and Territories. In many of these States the work has been extensive and thorough. As a result the actual conditions of the meadows and range lands have been ascertained; the various native forage plants have been collected and studied and their abundance, distribution, and relative value discovered. The forage plants cultivated in the various regions have also been studied and the capabilities of the regions for growing others not already grown have been in many instances determined. Special attention has been given to the causes of the deteriorated condition of the vast areas of grazing lands belonging to the public domain with a view to devising means for removing the causes and restoring the ranges to their original productiveness and carrying capacity. The particular problems calling for most immediate attention in each region have been determined and steps taken toward their solution. As a result of the knowledge thus gained the Division is able to recommend to farmers and stockmen in the various parts of the country the forage crops adapted to their conditions and special requirements, and also to carry on intelligently experiments with introduced forage plants likely to prove valuable in any particular region.

Not the least important results of these investigations has been the determination of the vast natural forage resources of the country. Our heritage in this respect has never been fully known and much less appreciated. In our search for grasses and forage plants to cultivate we have tried many from different parts of the world, while neglecting those all about us. There are growing within the bounds of the United States over one thousand species of grasses, and perhaps one hundred or more other plants of sufficient forage value to justify their investigation and cultivation. Of course, a great many of these grasses have little forage value, either on account of their scarcity, small size, or some quality which renders them unpalatable to stock. A large number of them are, however, of great value for hay and grazing purposes, and can probably not be surpassed by any in the world. Because they are native they have been too often not only neglected, but abused, and, in some cases, partially exterminated. It is certainly time we began to properly estimate and appreciate the great value of our native grasses and forage plants and take steps toward their conservation. Experiments have already shown that many of these most valuable grasses take kindly to cultivation and produce much larger quantities of hay and pasture when a little attention is given them. The buffalo grass, the grama grasses, blue grasses, the mesquites, the fescues, and the wheat and rye grasses, which furnish the bulk of the feed for the immense numbers of stock which roam over the public lands of the great West, are of inestimable value and could not be successfully replaced by any importations from foreign countries. To discover why this is true requires no great amount of research. These grasses have for ages grown under the prevailing unfavorable climatic conditions and have survived in the struggle for existence by reason of their having become adapted to these conditions. Judging from the wonderful feats which horticulturists have already performed in the selection and breeding of plants, there appears no reason why, by proper cultivation and selection, many of these native grasses should not be greatly improved, and in cases where they possess characteristics which tend to interfere with their successful cultivation, these may no doubt be eliminated. Some of these native grasses are at present excluded from becoming of great commercial importance on account of the difficulty of manipulating the seed. This difficulty is frequently the result of the presence of awns or hairs on the floral envelope enclosing the seed. These could, by careful selection and breeding, be gotten rid of. Hope for any great amount of success with introduced forage plants is only to be realized in case of those brought from regions whose climatic conditions are similar to ours. In all the field work special effort has been made to call the attention of stockmen and ranchmen to the value of the native grasses and to recommend means of perpetuating and increasing them. Investigations already carried on have demonstrated the possibility of restoring worn out range and pasture lands to nearly, if not quite, their original carrying capacity by entirely practical and economical methods of treatment in cases where the grasses have not been practically exterminated. Where there is still present a sufficient amount of good grass to produce seed there is a chance for restoring the range without great difficulty. Allowing the range a complete rest for a year or two produces results which astonish one who has never witnessed the experiment. Alternation in pasturing also produces very beneficial results, with less loss of grazing. In following this method pastures should be so arranged that the stock can be kept from certain areas for a sufficient length of time to allow the grasses to mature and scatter their seed, or to regain the vigor of their root system, which has been greatly injured by close grazing and trampling. Some of the best grazing grasses, as the blue grama, buffalo grass, and curly mesquite, reproduce most extensively by means of creeping rootstocks sent out by the plants, while others, as in the case of the bunch grasses, depend largely upon their seed for propagation. Alternation in pasturing gives the plants an opportunity to recuperate and regain their vigor. Another very efficient means of improvement is the disking of the range or pasture. The great advantage of this is that by the loosening of the soil the roots, which have been prevented from normal develment by the trampling of the stock and the lack of moisture supply,

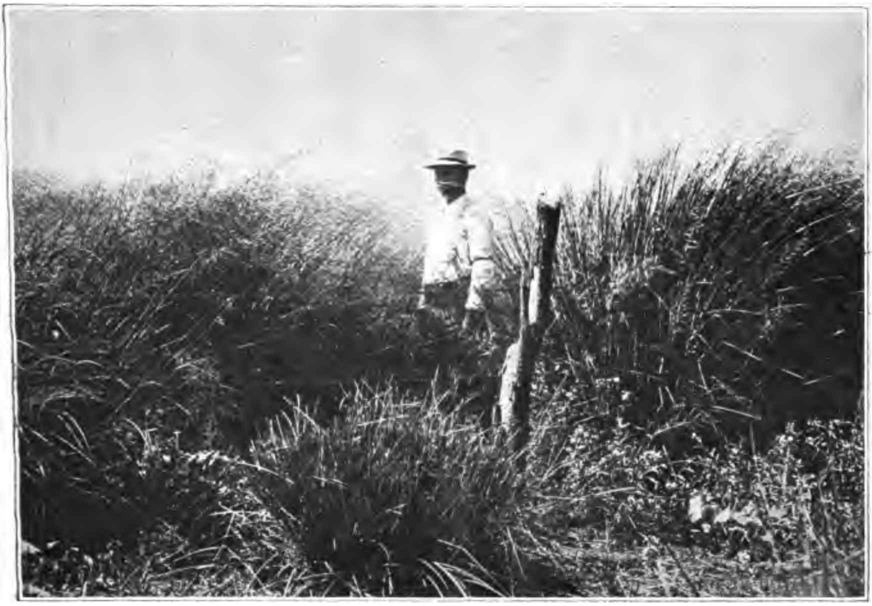


FIG. 1.—WRIGHT'S SACCATON (SPOROBOLUS WRIGHTII). IN THE SANTA CRUZ VALLEY, ARIZONA, SHOWING BUNCHES WHICH HAVE NOT BEEN GRAZED.

From a photograph by D. Griffiths.

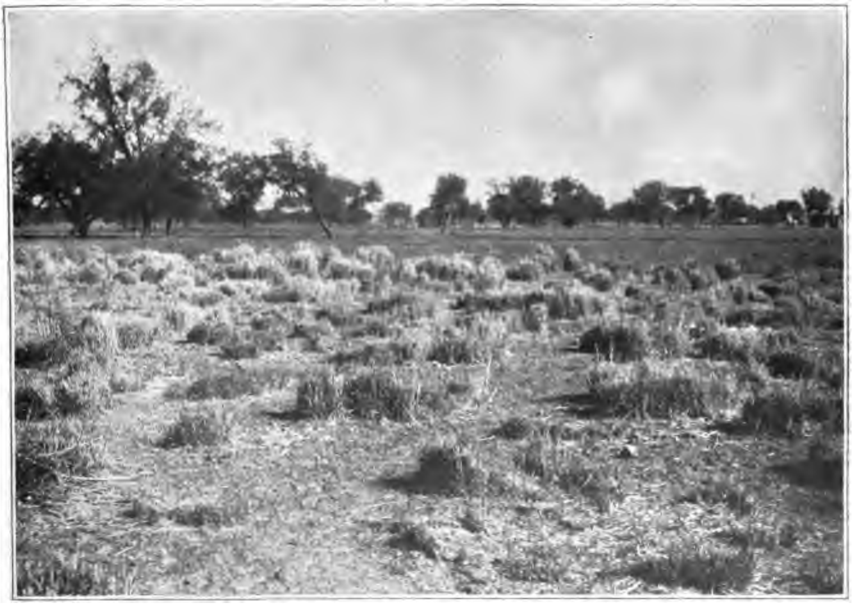


FIG. 2.—WRIGHT'S SACCATON, SHOWING ITS APPEARANCE AFTER BEING GRAZED. SAME LOCALITY.

From a photograph by D. Griffiths.

are given a chance to grow freely. The breaking of the soil also gives a chance for the storm waters to be absorbed, instead of rapidly running away over the hard surface of the soil. That these methods are feasible and very successful has been thoroughly demonstrated by the work of the Division in Texas. In cases where the native grasses have been largely destroyed, in addition to the disking it will be best to sow seed of the native grasses on the disked areas. These can frequently be secured by collecting them from protected places, where the grasses have been allowed to produce seed. Along the right of way of railroads the native grasses frequently grow luxuriantly, and produce an abundance of seed. We believe it will not be long, however, before seed of the more important of our native grasses will be collected or grown in commercial quantities and be obtainable on the market.

FORAGE PLANTS FOR ALKALI SOILS.

A great deal of attention has been given to the question of grasses and forage plants adapted to growth on alkali soils. There are very extensive areas throughout the West over which the soil is so impregnated with mineral salts, especially those of sodium and magnesium, that the majority of cultivated forage plants can not be grown. There are, however, a considerable number of native forage plants which have become adapted to the alkali soils and are able to grow upon them. Investigations along this line have shown that some of these native plants are of sufficient importance as forage plants to justify attempts toward introducing them into cultivation. This is particularly true of a number of the native saltbushes which are able to grow in soils containing large percentages of alkali and also to withstand excessive drought. Considerable quantities of seed of eight different species of native saltbushes were secured the past season and besides being grown on the experimental grounds at Washington they have been distributed to the experiment stations of the West for cultivation and trial. These plants are particularly valuable for sheep grazing. They are also relished by other stock and furnish a large amount of food at times when no other is available. Several other species of saltbush which are native of the alkali regions of the interior of Australia have also been introduced and grown on the alkali lands of the West and Southwest. The Division has distributed considerable quantities of seed of these saltbushes, especially the Australian saltbush (*Atriplex semibaccata*). This has been experimented with sufficiently to demonstrate its adaptability to cultivation in the warmer portions of the West and Southwest. Winter fat (*Eurotia lanata*) is another valuable forage plant which flourishes in alkali soils from Montana to Arizona. A number of grasses of considerable value also grow upon these alkali soils. Those which grow where the greatest amount of alkali is present are, however, not palatable to stock and are eaten by them only when better forage is not available. Quite a number of the better native grasses tolerate a considerable amount of alkali and by cultivation and selection could no doubt be made to withstand greater quantities.

SAND AND SOIL BINDERS.

As mentioned in discussing the various regions, considerable work has been done in investigating the sand and soil binding plants of the country. It has been found that we have a considerable number of excellect species of great value for this purpose. Besides the beach grass (*Ammophila arenaria*), sand rye grass (*Elymus arenarius*), bitter panic grass (*Panicum amarum*), creeping panic grass (*Panicum repens*), and the sea oats (*Uniola paniculata*) of the Atlantic and Gulf coasts, we have seaside blue grass (*Poa macrantha*) and several rye grasses on the Pacific coast and along the Columbia River. There are found growing in the interior also several important sand and soil binders. Redfield's grass (*Redfieldia flexuosa*) is one of the best of those found growing in the interior. It is a native of the sand hills of western Nebraska and Kansas. Indian millet (*Oryzopsis cuspidata*), sand grass (*Calamovilfa longifolia*), reed grass (*Phragmites vulgaris*), reed canary grass (*Phalaris arundinacea*), big cord grass (*Spartina cynosuroides*), blunt panic grass (*Panicum obtusum*), Johnson grass (*Andropogon halepensis*), and Vasey's needle grass (*Stipa vaseyi*) are important soil binders adapted to use on railway or river embankments, along ditches, or in other places where it is desirable to prevent the washing of the soil. Large quantities of seeds and roots of many of these species have been collected and distributed to various places for propagation and testing. In the case of the sand binders it has been found best to transplant the roots, as the sands frequently shift so rapidly that plants grown from seed are destroyed before they have made sufficient growth to be effective.

SPECIMENS SECURED.

An attempt has been made in connection with the field work to secure herbarium specimens of all the grasses and forage plants met with, in order that material may be at hand for study and comparison, for illustrative purposes, and for use in identifying the plants which are constantly being sent from different parts of the country. About 25,000 specimens have been secured by the Division force and field agents. Of these, about 9,000 have been added to the collection of the Department and the greater portion of the remainder distributed in exchange to the larger herbaria of the universities, botanical gardens, and experiment stations, not only in this country but throughout the world. In this way it has been possible to secure material, both specimens and seeds, of a great many foreign grasses and forage plants.

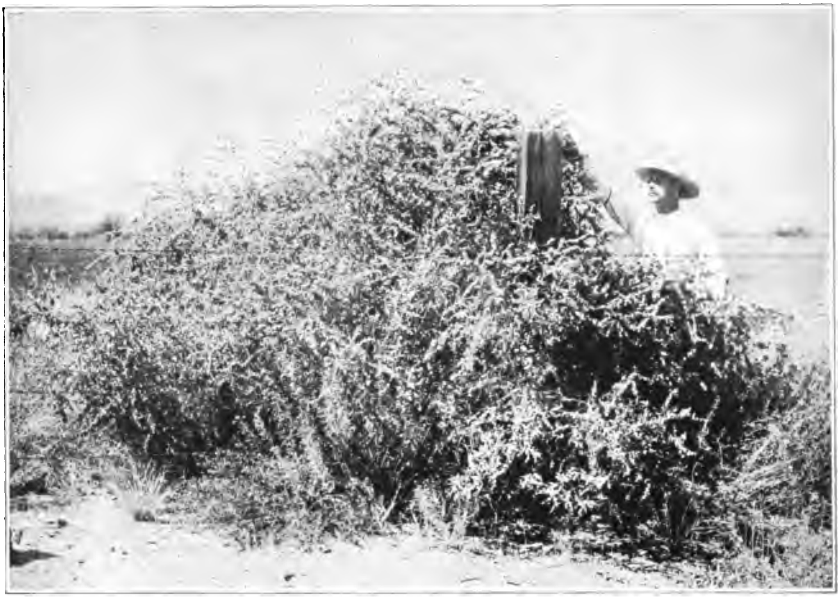


FIG. 1.—SHAD SCALE (ATRIPLEX CANESCENS). PLANT PROTECTED FROM GRAZING, NEAR TUCSON, ARIZ.

From a photograph by D. Griffiths.

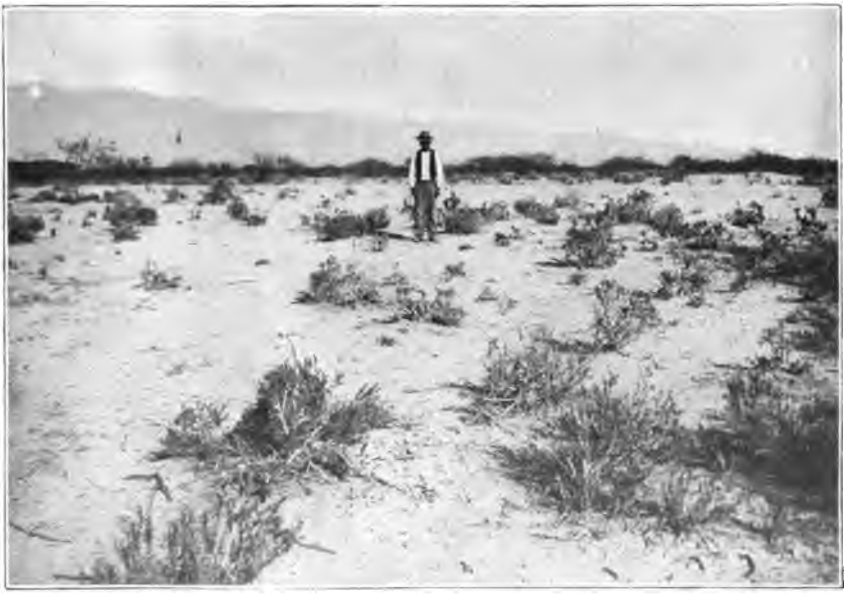


FIG. 2.—SHAD SCALE (ATRIPLEX CANESCENS). PLANTS IN THE SAME LOCALITY NEARLY DESTROYED BY OVERSTOCKING.

From a photograph by D. Griffiths.

The study of these collections has resulted in the discovery of about 75 species of grasses which had not before been described. The various bulletins containing studies on American grasses have been based in great part upon the study of these large collections. In fact, nearly all the publications of the Division are based either directly or indirectly upon the field work which has been done.

Besides the collection of specimens, a collection of seeds of the native grasses has been made a very important feature of the field work, especially during the past two seasons. Recognizing the great value and importance of the native forage products, special efforts have been made to show the possibilities in the way of cultivation and to encourage the production of seed by seedsmen. This will no doubt be done as soon as there is a sufficient demand for them. During the past season over four tons of seed of native grasses and forage plants were collected and distributed. As these seed were nearly all collected by hand, the amount of labor required may be appreciated. Besides the specimens and seeds, roots and sheaves have also been collected in quantity. In some cases it is impracticable to secure seed of a desirable plant, and in such cases roots were taken up and forwarded to various points for transplanting. Buffalo grass (*Bulbilis dactyloides*), Bermuda grass (*Cynodon dactylon*), Texas blue grass (*Poa arachnifera*), and others have been established and propagated at various places in this way. The sheaves have proven very useful for purposes of illustration and exhibition. A large collection was on exhibition at the Paris Exposition, and a collection has also been sent to the Pan-American Exposition. Another very interesting and important result of the work has been the securing of photographs illustrating all features of the work. In the neighborhood of a thousand negatives have thus been obtained. These are invaluable for illustrating the various publications of the Division. From them a series of lantern slides has also been made for use in connection with lectures and various features of the Division's work.

CONTROL OF GRAZING LANDS.

In the following paragraphs a brief account is given of the various methods adopted in other countries for controlling the public grazing lands. These may prove helpful in devising some method of controlling our own grazing lands.

THE AUSTRALIAN SYSTEMS.

An examination of the methods pursued by the different Australian colonies in the management of their grazing lands may be of interest and benefit in this connection. There are vast portions of the interior of Australia where, on account of an insufficient supply of moisture, grazing is the chief industry. The conditions that prevail are in many respects similar to those obtaining throughout portions of our semiarid West. During the early settlement and development of the Australian colonies attempts were made to restrict the occupation of the country to certain areas adjoining the coast settlements. As the population increased, however, and the development of the stock industry began, there was a gradual pushing beyond these boundaries into the vast interior. As the government at this time had made no provision for granting right or title to these lands, the pioneer stockmen, who were the first to occupy the country, were termed "squatters." Soon after the occupation of the grazing lands by squatters, difficulties arose similar to those which at present confront us. The government, however, began to devise means for disposing of these lands. The laws, however, were at first based upon an insufficient knowledge of the country and its requirements and did not always produce the desired results. At first in New South Wales plans were made for selling the land at a nominal figure. This was soon stopped, however, as the demand for land became so great and the alienation of large areas of the most valuable tracts was so rapid and led to so many troubles that the plan was abandoned. Selling lands at auction was also tried. These schemes proved unpopular and unsuccessful, largely because the land had not been properly classified. Later, various plans for renting the grazing lands were tried. Their first efforts along this line were not always successful, and frequently led to fraud and injustice. While they do not yet claim to have secured an entirely satisfactory arrangement, still the present method is far superior to no method, and the experiments and experiences which they have had may be of great value to us. The grazing lands are rented at present in areas ranging from 2,560 to 10,240 acres for a period of fifteen years. The tenant is obliged to make improvements, such as fences or some other equivalent. At the expiration of this lease an extension may be granted if it is considered by the land board that the range has been benefited by the occupation. The rents are appraised by local land boards every five years. Preference is given actual residents in the lease of areas lying near their property. Land of inferior character may be leased at auction.

In Victoria a plan of licensing the grazing of stock at a certain rate per head was tried. This, however, did not prove satisfactory, and later the plan was changed and provision made for renting the range lands, according to their estimated value based upon their carrying capacity, computed at the rate of 8d. per annum for sheep and 2s. per head for cattle. Tracts as at present leased vary in size from 7,500 to 40,000 acres. No person is allowed to hold more than one tract. If more than one application is made for renting the land, it is put up at auction. No lessee is allowed to assign or transfer his lease without

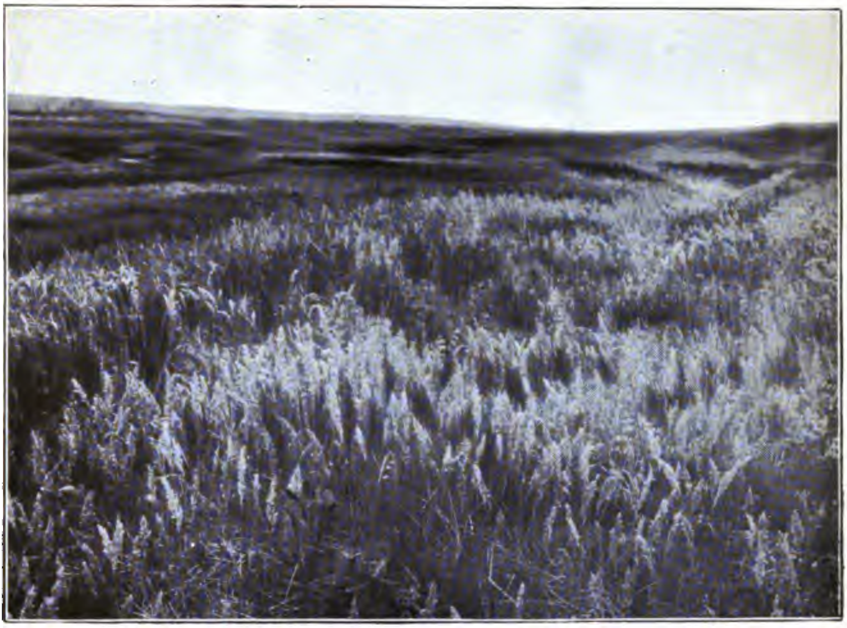


FIG. 1.—SEASIDE BLUE GRASS (POA MACRANTHA).
From a photograph taken near Morrison, Oregon, by A. B. Leckenby, 1899.

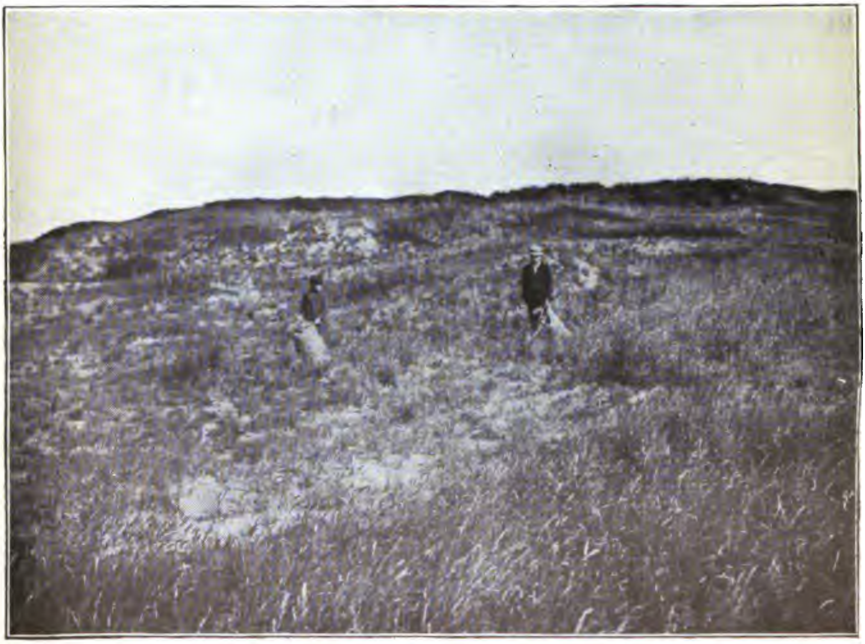


FIG. 2.—COLLECTING SEED OF SEASIDE BLUE GRASS NEAR MORRISON, OREGON.
From a photograph by A. B. Leckenby, 1899.

consent from the department having charge of the land. At present in Victoria the rental for the grazing lands is fixed by "valuers." The system as at present in operation in Victoria is said to have produced very satisfactory results.

In Queensland and Western Australia various methods similar to those tried in the other colonies have been in vogue at different times. Here as elsewhere the present plans are some modification of the lease system, the plans for the alienation of the land having been abandoned, as they have proved detrimental to the development and prosperity of the country.

CANADA.

Though the grazing lands of the Dominion are far less extensive and important than ours, still provision has been made for their control. The governor in council has authority to grant leases of unoccupied Dominion lands from time to time to any person or persons for such a term of years and at such a rent as may be deemed expedient, with the condition that if it is thought best by the Minister of the Interior to offer the land for settlement he may, on giving the lessee two years' notice, cancel the lease at any time during its term.

TEXAS.[1]

The public lands within the State of Texas are entirely under her control. The commissioner of the general land office of the State has charge of the land. The public lands are carefully and skillfully classified and valued and plats prepared. Provision is made for the sale of grazing lands, not to exceed four sections to the same settler, at a price not less than $1 per acre, but the purchaser must settle on one of the sections. The grazing lands are leased at not less than 3 cents per acre, the period of lease to be not more than five years. Formerly the possible period of lease was ten years. The person occupying the land has preference in re-leasing. Land may be advertised and let to the highest responsible bidder in such quantities and under such regulations as the commissioner may think best. Notwithstanding objections on the part of some to different phases of the Texas lease system, it seems to have proven fairly successful, and is certainly much preferable to no system at all.

STATE SCHOOL LANDS AND RAILROAD LANDS.

In Colorado and other States the lease system has been applied to the school lands with very satisfactory results. The large tracts of land granted to the transcontinental railways, including in some instances a strip 40 miles wide and covering large areas of grazing land, are being leased by the corporations. It will be seen from the foregoing that different countries, States, and corporations having possession of grazing lands have found leasing to be the most practical and advantageous method of controlling them.

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[1] We are indebted to Mr. J. J. Terrell, acting commissioner of the general land office of Texas, for the above facts.

The true measure of the success of any system of control is not the amount of income in dollars and cents derived each year, but the results to the grazing lands themselves and the general development and prosperity of the country. The funds arising from the lease of the lands might be very profitably used in developing the irrigation resources of the semiarid region.

SUGGESTIONS FOR FURTHER WORK.

As will be noted from the preceding account, the greatest and most important investigations of the Division are necessarily based upon field work. The various problems can not be studied successfully except under the natural conditions prevailing in the different regions. There are yet various phases of the work of the division, both scientific and economic, which require careful field observations and investigations. While from the work already done we are familiar with the condition of the ranges over considerable areas during certain seasons of the year, still it is desirable that a thorough knowledge of the conditions should be ascertained at different seasons. Investigations thus far have been carried on chiefly during the summer. In order, however, to get an adequate idea of the grazing lands, they should also be observed and studied during the spring and late autumn. An examination made during the most unfavorable season is apt to lead to an incorrect estimate of the capacity of the range, while an examination made when the range is at its best naturally leads to an error in the opposite direction.

The questions concerning the relation of grazing to the forests and water supply are still in need of considerable study, as conclusions based upon work carried on in one region may be entirely inapplicable to another. These problems are already being studied by the foresters and others interested in these subjects, but there is also need of careful work with special reference to the methods and manner of grazing these areas and the plants which furnish the forage. This work can no doubt be most economically and advantageously carried on in connection with the Division of Forestry. Aside from the special problems there are large areas of grazing lands in the West which have never been examined by our field workers. No work has been carried on by the Division in Nevada, and the greater portions of Arizona and New Mexico have never been studied. Little in the way of accurate observation has been done on the grazing lands and conditions in portions of California, Oregon, and Idaho. There are also special

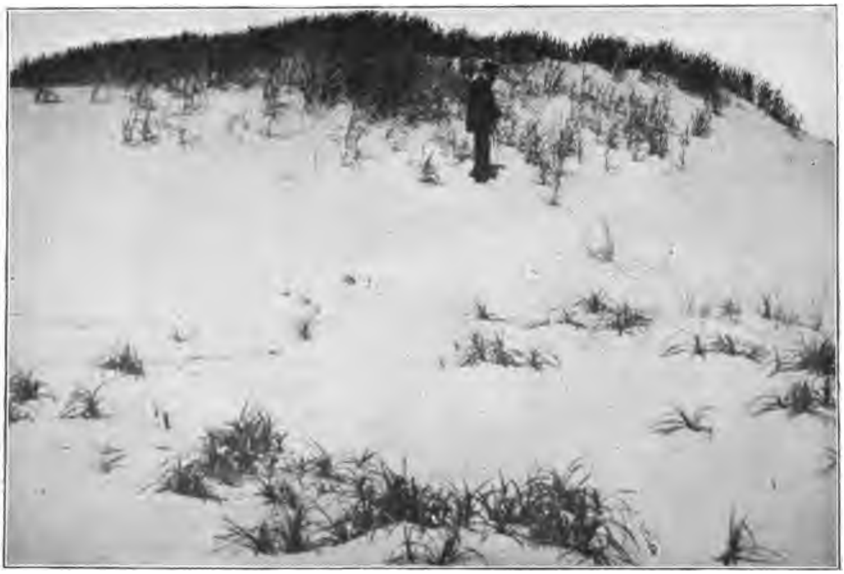

Fig. 1.—Sand Dune on the Pacific Coast. Sand Rye Grass (Elymus arenarius) covering the Top of the Dune and Big Head Sedge in the Foreground.

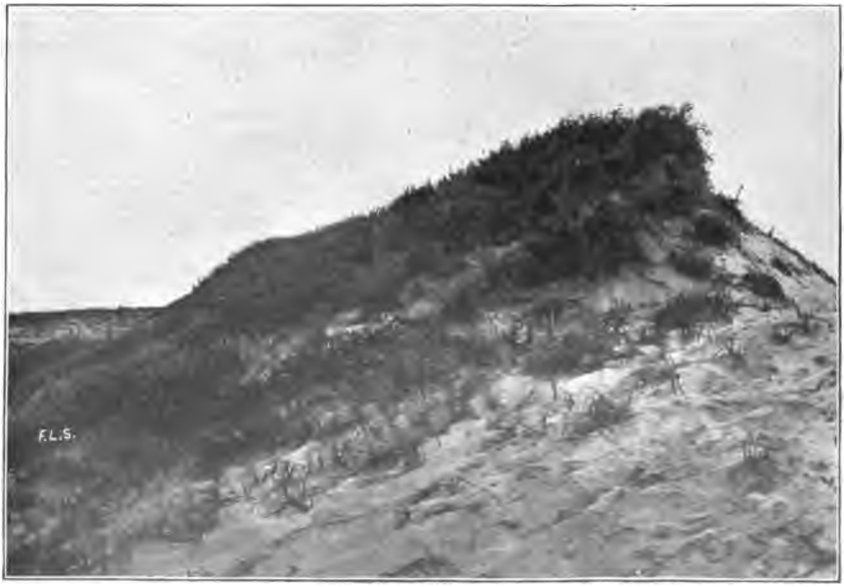

Fig. 2.—Sand Dune held by Seaside Blue Grass (Poa macrantha), near Seaside, Oregon.

From a photograph by F. Lamson-Scribner, 1899.

UNIV. OF OHIO

problems in New England and the Southern and Central States which are in need of careful field study.

There is also need of a much more careful and accurate study of the various species of native grasses in the field. The dried specimens, which are prepared for the herbarium, are very valuable for study and comparison, but they do not retain all the characteristics which are necessary to a full and satisfactory knowledge of the plants. It is gradually becoming recognized by students of plants that in order to obtain a thorough and accurate knowledge of the species they must be studied in the living state, growing under natural conditions and in their natural environment. Descriptions of species in order to be accurate and have the greatest scientific value should be made from the living, growing plant *in situ.* Drawings and illustrations should also be made from the same material. Good photographs are also very valuable for illustrating the habits of growth of various species.

Notwithstanding the great amount of literature published and widely distributed each year by the Division there seems to be a large number of people who should naturally be interested in and benefited by the work done who are not reached by this means. A plan somewhat similar to that adopted by the Division of Forestry would, no doubt, greatly increase the usefulness of the work. This is the giving of lectures on questions relating to grasses and forage plants at the various points visited by field workers. These lectures or talks, illustrated by stereopticon views, would bring much more forcibly to the attention of the people the various problems and methods of dealing with them. Under the stimulus of such direct and individual contact much greater and more important and beneficial results would be secured. Direct assistance and advice in the solution of any of the problems which present themselves would be a great advantage and result in greatly widening the field of influence and the practical importance of the work. The more closely we come in contact with the people who are struggling with the various forage problems the greater benefit will be derived by both. This contact will also promote a mutual understanding which will lead to a better appreciation of the difficulties to be overcome and a more thorough sympathy and cooperation in the work.

GRASSES AND FORAGE PLANTS.

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